

APPENDIX C

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INDUSTRIAL WASTE LANDFILL CLOSURE
TECHNICAL SPECIFICATIONS

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Notes: Attached

SECTION 01050

FIELD ENGINEERING AND SURVEYING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Survey Reference Points
- B. Examination
- C. General Survey Requirements
- D. Surveys of Work

1.2 RELATED SECTIONS

- A. Section 01300 - Submittals

1.3 MEASUREMENT AND PAYMENT

Not Used

1.4 SUBMITTALS

- A. Submit name, address, telephone number, and qualifications of Surveyor before starting survey work and within 10 days of Notice to Award. Surveyor shall be a registered professional land surveyor in the State of Delaware and shall be approved by Owner and Construction Manager.
- B. On request, submit documentation verifying accuracy of survey work.
- C. Submit as-built drawings and information for completed work as specified herein and in the individual Division 2 specification sections.
- D. For each as-built drawing or any other submitted survey information, submit certificate signed by Surveyor certifying that locations, elevations, and dimensions of the surveyed work are in conformance with the Contract Documents.

- E. The Contractor shall submit the Stake Inventory Plan to the Construction Manager for approval prior to placement of any stake. The Stake Inventory Plan should include the effective numbering of all stakes and subsequent verification of all stakes removed as appropriate.

1.5 PROJECT RECORD DOCUMENTS

- A. Contractor shall maintain a complete, accurate log of control and survey work as it progresses.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 SURVEY REFERENCE POINTS

- A. Existing survey control points are shown on the Drawings.

3.2 EXAMINATION

- A. Contractor shall verify locations and elevations of survey control points prior to starting work. Promptly notify Construction Manager of any discrepancies that are discovered.
- B. Verify layout information shown on the drawings, in relation to existing control points, before proceeding to layout the work. Locate and protect existing control points. Preserve permanent control points throughout construction.
- C. Utilities and construction indicated as existing are not guaranteed. Before beginning sitework, the Contractor shall investigate and verify the existence and locations of any utilities or other construction that could affect or be affected by the Work.

3.3 GENERAL SURVEY REQUIREMENTS

- A. All survey requirements defined within the Specifications shall be performed and be the responsibility of the Contractor.

- B. All stakes for surveying or other purposes should be installed and maintained with all precautions to protect the existing landfill liner system and the final cover liner system.
- C. Contractor shall establish a minimum of four permanent bench marks on site, referenced to established control points, at locations outside areas of construction. Record locations, with horizontal and vertical data, on Project Record Drawings.
- D. Benchmarks are to be checked monthly for accuracy by a professional land surveyor registered in the State of Delaware.
- E. Working from existing and new control points, establish markers to set lines and levels at each stage of construction, including all excavations and fills, and elsewhere as needed to properly locate each element of the Work. Calculate and measure required dimensions within indicated or recognized tolerances.
 - 1. Advise entities engaged in construction activities, of marked lines and levels provided for their use.
 - 2. As construction proceeds, check every major element for line, level, and plumb.
 - 3. Periodically check correctness of markers, temporary stakes, and hubs, etc. during work and adjust for work disturbance or subgrade settlements.
- F. Surveyor's Log: Maintain a surveyor's log of control and other survey work. Make this log available for reference.
 - 1. Record deviations from required lines and levels, and advise the Construction Manager when deviations that exceed indicated or recognized tolerances are detected. On Project Record Drawings, record deviations that are accepted and not corrected.
 - 2. On completion of each major work item, including but not limited to site preparation grading, final site grading, and other major work items specified in the individual Division 2 specification sections, prepare a certified survey plan showing dimensions, locations, angles, and elevations of construction and sitework.
- G. Site Improvements: Locate and lay out all Work, including any structures, piping, stakes for excavation fill and topsoil placement, and invert elevations by instrumentation and similar appropriate means.

- H. Existing Utilities: Furnish information necessary to adjust, move or relocate existing structures, utility poles, lines, services or other appurtenances located in or affected by construction. Coordinate with local authorities having jurisdiction.

3.4 SURVEYS OF WORK

- A. The Contractor shall employ at their expense a professional land surveyor, registered in the State of Delaware, for the purpose of performing surveys of completed work as described herein. (These as-build surveys shall be based on the horizontal and vertical control as depicted on the Drawings.) In the case of the Final Grading Survey, as described below, a plan of the existing site topography shall be developed in the form of a mylar at a scale of 1 inch equals 60 feet with a one-foot contour interval. In addition, cross-sections shall be taken at a minimum of 100-foot intervals longitudinally and laterally across the site to the limits of Work, unless otherwise approved by the Construction Manager. Each section line shall show a spot elevation at an interval of 100 feet along each section line, as well as elevations at all grade change locations and stormwater conveyance pipelines (including centerline and invert elevations). All section lines and their locations shall be coincident for each of the surveys described below. Each topographic survey plan shall be dated and bear the seal of the surveyor engaged in the work. The required surveys include:
1. Interim Grading Survey Plans of the site, or portion of the site, after the periodic completion of excavation and fill placement activities. These surveys shall be performed as deemed appropriate by the Construction Manager, and/or Contractor to minimize/eliminate possible soil shrinkage/settlement effects and to serve as the basis for earthwork progress payments, and must therefore accompany all invoices related to this Work. The Interim Survey information need only include the cross-sectional data, as described previously, for those areas where work was performed since the date of the previous survey. (This may include or partially incorporate a re-survey of a given area immediately prior to disturbance of the area due to excavation or fill activities). It is left to the Contractor's discretion as to the number of Interim Surveys required during the overall construction period.
 2. Preparatory Grading Survey Plan showing grades achieved following construction of the prepared subgrade, consistent with the Site Preparation Plan drawings. This plan(s) shall show prepared subgrade elevations of the entire disturbed area and shall include the limits of completed excavations and fills, locations of stormwater channels, and other work associated with subgrade preparation. The plan shall serve as a final record of all completed prepared subgrade construction.

3. Final Grading Plan showing grade after completion of all earthwork activities and topsoil placement. The land surveyor will prepare a plan that will show, at a minimum, the following information:

- Location and boundary of the closed LF, including the coordinates of the State of Delaware state plane grid system.
- Area covered by the cover system and ground surface elevations at the nodal points of a 100-foot grid across the LF.
- Security fences, roadways, drainage trenches, and any known utilities crossing or within the LF.
- Groundwater monitoring wells
- Benchmarks
- Notes to restrict disturbance of the LF cover and to indicate the types of waste deposited in the closed LF.
- Type and quantity of waste.

The plan shall serve as a record of all finished grades and will be filed with the Recorder of Deeds, New Castle County, Delaware.

4. Other plans as required within the individual Division 2 specification sections.

B. The Interim and Preparatory Grading Survey Plans, as described above, shall be submitted within a two (2)-week period from the cessation of a particular surveying activity. The Final Grading Survey Plan shall be submitted within a four (4)-week period from the cessation of surveying. The Contractor shall retain a mylar copy of each plan in their field office during the Project. Each plan shall bear the seal of the surveyor engaged in the Work.

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

4.1 QUALITY ASSURANCE

A. Perform the Work in accordance with the Construction Quality Assurance Plan.

4.2 QUALITY CONTROL

- A. Quality control is described in the Construction Quality Assurance Plan and these specifications.

END OF SECTION

SECTION 01400

QUALITY CONTROL AND QUALITY ASSURANCE

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Quality Control (QC) of Installation.
- B. Quality Assurance (QA).
- C. Tolerances.
- D. References and Standards.
- E. Inspection and Testing Services.
- F. Manufacturers' Field Services.
- G. Certificates of Compliance

1.2 RELATED SECTIONS

- A. Section 01300 – Submittals
- B. Section 02000 – Site Work
- C. Section 02100 – Site Preparation
- D. Section 02200 – Earthwork
- E. Section 02205 – Soil Materials
- F. Section 02207 – Aggregate Materials
- G. Section 02270 – Soil Erosion and Sediment Control Measures
- H. Section 02290 – Geomembrane for Final Cover System
- I. Section 02291 – Drainage Geocomposite
- J. Section 02292 – Geotextiles

- K. Section 02350 – Gas Vent/Monitoring System
- L. Section 02831 – Chain Link Fences and Gates
- M. Section 02900 – Monitoring Wells Modification

1.3 MEASUREMENT AND PAYMENT

Not Used.

1.4 QUALITY CONTROL (QC) OF INSTALLATION

- A. The Contractor is responsible for all quality control of the Work. Monitor quality control over Suppliers, Manufacturers, products, Subcontractor services, site conditions, and workmanship, to produce Work of specified quality.
- B. Comply with Manufacturers' instructions, including each step in sequence.
- C. Should Manufacturers' instructions conflict with Contract Documents, request clarification from Construction Manager before proceeding.
- D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- E. Perform Work by persons qualified to produce required and specified quality.
- F. During freezing or inclement weather, or other adverse conditions, no Work shall be performed except that which can be performed in a manner that will ensure quality construction throughout and not contradict Manufacturer's instructions, as approved by the Construction Manager.
- G. All stakes for surveying or other purposes shall be installed and maintained with all precautions to protect the existing landfill liner system and the final cover liner system. The Contractor shall submit the Stake Inventory Plan to the Construction Manager for approval prior to placement of any stake. The Stake Inventory Plan should include the effective numbering of all stakes and subsequent verification of all stakes removed as appropriate.
- H. Perform quality control/quality assurance inspections and testing of the materials and construction to include, at a minimum, the requirements of this Section.

1.5 QUALITY ASSURANCE (QA)

- A. The Contractor is responsible for quality assurance of the work.
- B. The Contractor shall submit to the Construction Manager within 10 days of Notice of Award a written Construction Quality Assurance Plan that, at a minimum, discusses the following QA activities:
 - 1. Observation of construction activities.
 - 2. Review of QC procedures implemented and QC data that is to be submitted to the Construction Manager.
 - 3. Documentation that the work is performed in accordance with the Design Drawings and Specifications.
 - 4. Performance of QA sampling and testing to assess QC sampling and testing procedures.
 - 5. Verification that QC test equipment meet testing and calibration requirements and that QC tests are conducted in accordance with standardized procedures defined in design documents.
 - 6. Identification of QC work that should be accepted and submitted to Construction Manager, rejected, or further evaluated.
 - 7. Verification that any required corrective measures are implemented.
 - 8. Collection and maintenance of samples.
 - 9. Inspection of delivered materials.
 - 10. Review of results from QC and confirmatory QA laboratory and field testing.
 - 11. Reporting of deviations from the Design Drawings and Specifications.
 - 12. Preparation of weekly QA reports summarizing QA inspections and transmitting necessary documentation to the Construction Manager.
 - 13. Qualifications of the Contractor's proposed QA team.

1.6 TOLERANCES

- A. Monitor fabrication and installation tolerance control of Products to produce acceptable Work. Do not permit tolerances to accumulate.
- B. Comply with Manufacturers' tolerances. Should Manufacturers' tolerances conflict with Contract Documents, request clarification from Construction Manager before proceeding.
- C. Adjust Products to appropriate dimensions; position before securing Products in place.

1.7 REFERENCES AND STANDARDS

- A. For Products or workmanship specified by association, trade, or other consensus standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.
- B. Conform to reference standard by date of issue current on date of Contract Documents, except where a specific date is established by code.
- C. Obtain copies of standards where required by product specification sections.
- D. Neither the contractual relationships, duties, responsibilities of the parties in Contract nor those of the Construction Manager shall be altered from the Contract Documents by mention or inference otherwise in any reference document.

1.8 INSPECTION AND TESTING SERVICES

- A. The Contractor shall appoint, employ, and pay for services of qualified personnel that are acceptable to the Owner to perform laboratory testing and field inspection and testing. The Contractor shall submit for review by the Construction Manager the qualifications and experience of personnel proposed to perform quality control services, including information (e.g., training records) to document personnel qualifications and necessary certifications within 10 days of Notice of Award. Submit name, address, and telephone number of each independent testing and inspection firm, if any, also proposed for quality control services.
- B. The qualified personnel (employed by the Contractor or independent firm(s)) shall perform laboratory testing, field inspection and testing, and other services specified in individual specification sections.

- C. The qualified personnel shall obtain field samples at the site and at off-site locations as required by individual specification sections.
- D. Five copies of all laboratory and field test reports shall be submitted to the Construction Manager. The reports shall indicate observations and results of tests and state if they are in compliance or not with the Contract Documents.
- E. The Owner and Construction Manager reserve the right to perform additional QA/QC inspections, tests, and analyses. The Contractor shall cooperate with quality control and quality assurance personnel employed by the Owner by furnishing samples of materials, equipment, tools, storage, and by providing access and assistance. The time needed for the firm(s) to take samples and perform tests shall be included in the project schedule and incorporated into the Contractor's price.
- F. The Contractor shall notify the Construction Manager 24 hours prior to the time that field operations will require independent confirmatory quality assurance testing and engineering inspection in accordance with the Specifications.
- G. The Contractor shall make arrangements and pay for additional samples and tests required for Contractor's use.

1.9 MANUFACTURERS' FIELD SERVICES

- A. The Contractor shall provide, schedule, and pay for all costs for a qualified Manufacturer's representative to be present at the site when required by the individual sections of the Specifications.
- B. The Manufacturer's representative shall record all observations and recommendations. The Contractor shall submit to the Construction Manager five (5) copies of the Manufacturer representative's written report indicating field activities, results of examinations or surveys, and recommendations.

1.10 CERTIFICATES OF COMPLIANCE

- A. For certain materials and products, certificates of compliance are required in lieu of specified sampling and testing procedures. Any certificates required for demonstrating proof of compliance of materials with specification requirements shall be submitted in duplicate with each lot of material delivered to the work. The lot so certified shall be clearly identified by the certificate. Certificates shall be signed by an authorized representative of the Producer or Manufacturer and shall state that the material complies in all respects with the Contract requirements. In the case of multiple shipments, each shipment shall be accompanied by a certificate of compliance.

- B. The certificate of compliance shall be accompanied by a certified copy of test results or shall state that such test results are on file with the Producer or Manufacturer and shall be furnished to the Construction Manager on request.
- C. The Construction Manager reserves the right to refuse to permit the use of certain materials on the basis of a certificate of compliance and such refusal shall not result in any additional charges or contract time extensions to the Owner.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 GENERAL

- A. Specific quality control testing is required to be performed by the Contractor for specific portions of the Work. Generalized testing requirements are described in each specification section. Quality control testing by the Contractor shall, at a minimum, include the specific testing frequencies and special testing requirements for each portion of the Work as detailed in each specification section.

END OF SECTION

SECTION 02000

SITE WORK

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. General Scope of Site Work Activities

1.2 RELATED SECTIONS

- A. Section 01300 - Submittals
- B. Section 01390 - Preparation of a Health & Safety Plan
- C. Section 01400 - Quality Control and Quality Assurance
- D. Section 02100 - Site Preparation
- E. Section 02200 - Earthwork
- F. Section 02205 - Soil Materials
- G. Section 02207 - Aggregate Materials
- H. Section 02270 - Soil Erosion and Sediment Control Measures
- I. Section 02280 – Prefabricated Vertical Drains
- J. Section 02290 - Geomembrane For Final Cover System
- K. Section 02291 - Gas Collection/Drainage Geocomposite
- L. Section 02292 - Geotextiles
- M. Section 02295 - Direct Shear Interface Testing
- N. Section 02350 - Gas Vent/Monitoring System
- O. Section 02831 - Chain Link Fences and Gates
- P. Section 02900 - Monitoring Wells Modification

1.3 DESCRIPTION

- A. Division 2 of these Specifications addresses preparing surfaces for excavation or filling; excavating stormwater channels and basins; filling to achieve subgrade (preparatory) lines and grades; installation of a final cover system with components including a cushioning geotextile, geomembrane liner, filter geotextile, geonet drainage layer, vegetative cover soil and topsoil; restoration of the area and maintenance of the restored area. Appropriate erosion and sediment control measures and stormwater management controls shall be implemented throughout the Work.
- B. The Work includes the furnishing of all labor, supervision, materials, equipment, quality control, permits, services, and operations required to successfully complete the installation of all work, and related work as indicated by the Drawings and Specifications, including but not necessarily limited to the following:
 - 1. Site Preparation
 - 2. Earthwork
 - 3. Surface Water Drainage
 - 4. Slope Protection
 - 5. Erosion and Sediment Control
 - 6. Stormwater Channels
 - 7. Gas Vent/Monitoring System
 - 8. Geotextile
 - 9. Geomembrane Liner
 - 10. Geonet Drainage Layer
 - 11. Fences and Gates
 - 12. Landscaping, Seeding and Ground Cover
 - 13. Maintenance of Restored Area

1.4 SUBMITTALS

All submittals shall be prepared and submitted in accordance with Section 01300 and the specific requirements of the pertinent specification sections of this Division.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

Execution of the Work shall be in accordance with the respective specification sections of this Division. Contractor shall be responsible for locating all subsurface utilities prior to start of work.

All work shall be done in a manner protective of the existing landfill liner system, all installed landfill control systems, and the groundwater monitoring wells.

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

Quality assurance/quality control of the Work shall be in accordance with the respective specification sections of this Division.

END OF SECTION

SECTION 02100

SITE PREPARATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Protection of Existing Features
- B. Removal of Temporary Synthetic Cover
- C. Clearing and Grubbing of Trees, Shrubs, Vegetation, and Other Organic Matter
- D. Removal and Disposal of Debris and Cleared/Grubbed Material
- E. Cutting and Chipping of Cleared Material
- F. Fence Removal and Replacement
- G. Protection and Abandonment of Monitoring Wells
- H. Leachate Collection Manhole/Pump Station Extension and Modifications

1.2 RELATED SECTIONS

- A. Section 01300 - Submittals
- B. Section 01400 - Quality Control and Quality Assurance
- C. Section 02200 - Earthwork
- D. Section 02205 - Soil Materials
- E. Section 02270 - Soil Erosion and Sediment Control Measures
- F. Section 02831 - Chain Link Fences and Gates
- G. Section 02900 – Monitoring Wells Modification

1.3 MEASUREMENTS AND PAYMENT

- A. Removal and Disposal of Temporary Synthetic Cover: Lump Sum. Includes removing, transporting, and disposing of temporary synthetic cover from the Industrial Waste Landfill as appropriate. All required licensing, permitting, and manifesting for transportation and disposal of material is also included. Removal and disposal of the material, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.
- B. Clearing Inside and Outside Landfill Limits: Lump Sum. Includes clearing within the limits of work and loading and hauling of cleared materials in preparation for subsequent cutting, chipping, and off-site disposal. Clearing inside and outside the landfill limits, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.
- C. Grubbing Outside Landfill Limits: Lump Sum. Includes grubbing, where directed by the Construction Manager, as needed outside the limits of the landfill and loading and hauling grubbed materials in preparation for subsequent cutting and off-site disposal. Grubbing outside landfill limits, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.
- D. Chipping and Stockpiling Cleared Material: Lump Sum. Includes chipping cleared aboveground trees, brush, and other vegetation, and loading and hauling chipped material to an on-site stockpile. Chipping of above-ground material, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.
- E. Stump Grinding Outside Landfill Limits: Lump Sum. Includes grinding any existing stumps, and stumps of cleared trees and brush, down to surrounding ground surface outside the limits of cover system construction, where directed by the Construction Manager, and loading, hauling, and disposal of chipped stump material to an on-site stockpile. Stump grinding, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.
- F. Disposal of Cleared Material: Lump Sum. Includes preparing, transporting, delivering, and placing cleared materials on Owner's property at the Industrial Waste Landfill as appropriate, according to the Drawings. All required cutting, licensing, permitting, and manifesting for transportation and disposal of material is also included. Disposal of cleared material, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.
- G. Disposal of Debris: Lump Sum. Includes preparing, transporting, delivering, and placing debris outside the horizontal limits of the landfill as directed by the

Construction Manager. All required cutting, licensing, permitting, and manifesting for transportation and disposal of material is also included. Disposal of debris, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.

- H. Disposal of Grubbed Material from Excavation Areas Outside Landfill Limits: Lump Sum. Includes preparing, transporting, delivering, and placing grubbed materials at the Industrial Waste Landfill. All required cutting, licensing, permitting, and manifesting for transportation and disposal of grubbed material shall be included. Disposal of grubbed material, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.
- I. Fence Relocation: Payment in accordance with Section 02831 - Chain Link Fences and Gates.
- J. Removal of Existing Facilities: Lump Sum. Includes removal and disposal of existing facilities (i.e. asphalt, utility poles, pumping station) in accordance with Drawings. Removal and disposal, as accepted by the Construction Manager, will be paid for on a lump sum basis in accordance with the Bid Schedule.

1.4 SUBMITTALS

- A. Submit work plan and schedule for completing site preparation activities.
- B. Submit product information, satisfying the requirements of Section 02831, for new fencing.
- C. Submit product information for temporary protection fencing.

1.5 DESCRIPTION

- A. Work covered in this Section shall consist of furnishing the labor, materials, tools, equipment, incidentals, quality control, and services necessary to complete clearing and grubbing of the entire area within the limits of work, as indicated in this Section and on the Drawings, and to remove and re-install the existing chain link fence as indicated on the Drawings or as deemed necessary to perform the work, as approved by the Construction Manager.
- B. Clearing is the removal from the ground surface and proper disposal of trees, brush, shrubs, downed timber, decayed wood, other vegetation, rubbish, and debris, as well as the removal and relocation of fences and incidental structures.

Cleared materials (except for fencing) shall be disposed of as specified herein or directed by the Construction Manager.

- C. Grubbing is the removal and proper disposal of all stumps, buried logs, roots larger than 1 inch in diameter, matted roots, organic materials, debris, foundations, utilities or other abandoned structures. Grubbed materials shall be disposed of as specified herein or directed by the Construction Manager.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

3.1 PREPARATION

- A. Verify that existing trees, shrubs and other vegetation designated to remain are tagged or identified for protection.
- B. For cleared and grubbed materials approved for on-site use or disposal, select location(s) for placing removed materials and identify temporary access to location(s). Obtain Construction Manager's approval.
- C. For debris, select location(s) outside the horizontal limits of the landfill for disposal of removed debris and identify temporary access to location(s). Obtain Construction Manager's approval. If no location outside the landfill within Refinery property is available, transport to appropriate off-site disposal facility approved by the Construction Manager.

3.2 REMOVAL OF TEMPORARY SYNTHETIC COVER

- A. Remove existing temporary synthetic cover (20-mil. polyethylene geomembrane) that covers entire landfill surface.
- B. Remove, load, haul and dispose materials as approved by the Construction Manager.

3.3 PROTECTION OF EXISTING FEATURES

- A. All work shall be done in a manner protective of the existing landfill liner system, all installed landfill control systems, and the groundwater monitoring wells.
- B. Protect groundwater monitoring wells, benchmarks, survey control points, and existing structures and utilities to remain from damage or disturbance.
- C. Contractor shall replace in-kind any damaged or disturbed structures, utilities or other surface features at no cost to Owner.
- D. All stakes for surveying or other purposes shall be installed and maintained with all precautions to protect the existing landfill liner system and the final cover liner system. The Contractor shall submit the Stake Inventory Plan to the Construction Manager for approval prior to placement of any stake. The Stake Inventory Plan should include the effective numbering of all stakes and subsequent verification of all stakes removed as appropriate.
- E. Contractor shall take whatever precautions are necessary to prevent soil erosion, water pollution, and other conditions detrimental to the environment. Should such environmentally-detrimental conditions develop due to site clearing operations, Contractor shall correct the conditions immediately. All measures of sediment and erosion control plans, Specification Section 02270, and as required by New Castle County, shall be followed.
- F. Contractor shall not permit human waste, garbage, kitchen or laundry wash, manure, sawdust, or other environmentally-destructive material to enter any channel, stream, watercourse, or pond.
- G. Existing Roads: Conduct site clearing operations to ensure minimum interference with access roads, walking areas, and other adjacent facilities. Do not close or obstruct streets, walkways, or other occupied or used facilities.
- H. Protection of Existing Trees and Vegetation: Protect existing trees and other vegetation designated to remain in place against cutting, breaking or skinning of roots, skinning and bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary guards to protect trees and vegetation to be left standing.
 - 1. Provide protection for roots over 1-1/2" diameter cut during construction operations. Coat cut faces with emulsified asphalt, or other acceptable coating, formulated for use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out; cover with earth as soon as possible.

2. Repair or replace trees and vegetation indicated to remain which are damaged by construction operations, in a manner acceptable to the Construction Manager. Employ licensed arborist to repair damages to trees and shrubs.

3.4 CLEARING AND GRUBBING

- A. Prior to site clearing, the Contractor shall install erosion and sediment controls as indicated on the Drawings and specified in Section 02270 of these Specifications to control erosion and the transport of sediment beyond the Work limits.
- B. Clear all items specified herein to the limits indicated and remove cleared and grubbed material. Do not start earthwork operations in areas where clearing and grubbing is not complete, with the exception that stumps, large roots and any subsurface debris may be removed concurrently with excavation.
- C. Clearing and grubbing shall extend to the limits required to complete the Work as described in this Section and as shown on the Drawings.
- D. Clear and grub entire area within limits of the cover system and perimeter stormwater drainage system, including channels and basins, if any. Grubbing within the limits of the cover system, if required, shall extend to a depth of 36 inches below preparatory grades or existing grades, whichever is deeper. Outside the limits of cover system, clear and grub areas where excavation or filling is required. Grind stumps to existing ground and remove surface debris, if any, in areas where fill is required, as approved by the Construction Manager. Grub stumps and root mats in excavation areas to a depth of not less than 1 foot below preparatory grades. Depressions made by the removal of stumps, roots, or subsurface debris shall be filled with compacted soil materials suitable for vegetative soil cover.
- E. Load, haul and place materials approved by the Construction Manager for chipping/mulching or off-site disposal.
- F. Burning of any material shall not be permitted on the site.
- G. Above-ground trees, tree limbs and branches, and shrubs shall be properly cut and chipped, to the extent practicable, for subsequent use as on-site mulch material for erosion control. Stockpile all chipped material where approved by the Construction Manager.
- H. Above-ground trees, limbs, branches and shrubs which cannot be practicably chipped and stumps, buried logs, roots and root mass shall be properly cut and transported to the designated Owner's property.

- I. All cleared and grubbed materials shall be immediately cut and properly disposed of as specified at approved on-site or off-site locations.

3.5 FENCE REMOVAL

- A. During site clearing, the Contractor shall remove and relocate (portion) the existing fence located within the proposed work area where shown on the Drawings. Site security shall be maintained along the existing perimeter fence alignment during non-working hours using temporary plastic protection fence, or as otherwise approved by the Construction Manager. To the extent practicable, the Contractor shall protect fencing to remain. Fencing inadvertently damaged by the Contractor shall be replaced by the Contractor in accordance with Section 02831. The Contractor shall supply and install new fencing and gates in accordance with Section 02831 where necessary to re-establish the final fence line, as indicated on the Drawings.

3.6 REMOVAL OF CULVERT PIPES AND OTHER FEATURES

- A. Existing culvert pipes, channel lining materials and other miscellaneous structures scheduled for removal and disposal shall be in accordance with the Drawings and Specification Section 02200 3.2. Existing pipes to be placed within the horizontal limits of the Industrial Waste Landfill for disposal shall be placed within the landfill fill material at least 24 inches below preparatory grades (geomembrane barrier layer). All pipes shall be crushed flat prior to placement in the landfill. All material disposed of shall be laid flat and backfilled to minimize voids.

3.7 MODIFICATION AND ABANDONMENT OF EXISTING MONITORING WELLS

- A. All monitoring wells to remain around which significant change in ground surface elevation is proposed shall be modified as shown on the Drawings and in accordance with Section 02900 and DNREC regulations.
- B. All monitoring wells to be removed shall be abandoned in accordance with DNREC regulations with appropriate and complete documentation.

3.8 LEACHATE COLLECTION MANHOLE/PUMP STATION EXTENSION AND MODIFICATIONS

- A. Contractor shall vertically extend the existing leachate collection manhole and complete all equipment and ancillary modifications to accommodate the extension to provide for continued operation of the pump station within the manhole.

Attachment A to this specification provides 'as-built' showing the general configuration and equipment arrangement associated with the existing manhole/pump station along with general dimensional/design considerations for completing the required vertical extension.

- B. Contractor shall engage a specialty contractor(s) to design and install the manhole extension and all required pump station modifications consistent with the Attachment A information. Contractor shall submit shop drawings, work plans, manufacturer installation guidelines/recommendations, quality control/assurance requirements and supporting calculations clarifying the suitability and operations of the materials, equipment and approach proposed to complete the work for approval by the Construction Manager.

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

- 4.1 Perform work in accordance with the Construction Quality Assurance Plan.
- 4.2 Satisfy all requirements of Section 02200, Part 4, regarding soil materials source quality control, soil materials quality control testing, and subgrade preparation and grading quality control.

END OF SECTION

ATTACHMENT A

‘AS-BUILT’ INFORMATION
FOR
INDUSTRIAL WASTE LANDFILL
LEACHATE COLLECTION MANHOLE/PUMP STATION

2111017/6.1.4.1

1993-11-03

StarEnterprise

P. M. Laabs
Plant Manager
Delaware City Refinery



EH&S DEPT

CF HERSEBA

2000 Wrangle Hill Road
Delaware City, DE 19706
302 834 6000
Fax 302 834 6498

MG MB
MH MB
MMM MB
RJN MB
EMP MB
WJT MB
CJA MB

November 3, 1993

Mr. Richard A. Folmsbee, Manager
Solid Waste Management Section
DNREC
P. O. Box 1401
Dover, DE 19903

LP
FILE

Dear Mr. Folmsbee:

Please refer to Permit SW-92/05 for the construction of the Industrial Landfill located at Star Enterprise's Delaware City Plant, Delaware City, Delaware.

Pursuant to Section IX. A. 1. of the above-referenced permit, Star Enterprise is notifying your department of intent to begin trial operation of Cell 1 immediately upon receiving written approval from your office to begin the trial operation.

Attached as required is Duffield Inc.'s certification stating, with exceptions noted, that the cell is ready for trial operation.

If you have any questions or we can be of further assistance, please contact Michael Harasika at 834-6405.

Sincerely,

STAR ENTERPRISE

P. M. Laabs
P. M. Laabs

MH/
Attachment

cc: Indra Batra - DNREC
R. Martin - DNREC

Leg Permit Hufsu
File: ENV-PC-DNREC-INDUSTRIAL LANDFILL
GOV 5-8-2.135R-2

bcc: J. K. Smith Northborough HOLLISTON



OFFICES IN
WILMINGTON, DE
ELKTON, MD

DUFFIELD ASSOCIATES INC
CONSULTANTS IN THE GEOSCIENCES

November 2, 1993

JAMES F. DUFFIELD P.E. Mr. Michael Harasika
JEFFREY M. BROSS P.E. STAR Enterprise
GLENN K. ELLIOTT P.G. Delaware City Plant
R. DAVID CHARLES P.E. 2000 Wrangle Hill Road
RANDALL M. HORNE P.E. Delaware City, DE 19706

W.O. 1867.NK.01
RE: Trial Operation - Cell No. 1
STAR Industrial Waste Landfill
Delaware City Refinery

Dear Mr. Harasika:

We have prepared this correspondence to provide Duffield Associates' observations and professional opinion concerning the construction of Cell No. 1 of the STAR Delaware City Refinery Industrial Waste Landfill. In addition, we have included our comments concerning the proposed trial operation for this cell.

In accordance with Section IX, paragraph A.1 of Permit No. SW-92/05, issued to STAR Enterprise (STAR) by the Delaware Department of Natural Resources and Environmental Control (DNREC), a trial operation of the first cell (Cell No. 1) of the Industrial Waste Landfill (IWL) requires "certification" by a professional engineer, registered in the state of Delaware, that the construction of the cell has been completed in accordance with the specifications described in the permit.

Duffield Associates, Inc. is the Construction Quality Assurance (CQA) Officer for the STAR IWL project. Our comments as CQA Officer, concern compliance with the project plans, technical specifications, and Construction Quality Assurance/Quality Control (CQA/QC) Plan as prepared by Duffield Associates, Inc. As CQA Officer, we have been responsible for coordinating implementation of the approved CQA/QC plan. This coordination has included regular site visits, review of the contractors' submittals, review of construction review personnel (CRP) daily field reports, and providing engineering consultation to STAR and CRP personnel. Full time on-site CRP personnel have been provided by VFL Technology (VFL), and these personnel report directly to the CQA Officer on matters of quality assurance.

Mr. Michael Harasika
November 2, 1993
Page 2

Cell No. 1 Construction

The Cell No. 1 dual containment geomembrane liner system was completed in October, 1993. Based on our observations and review of ongoing construction, and the available liner and soils testing data, it is our opinion that the IWL Cell No. 1 has generally been constructed in accordance with the contract plans and technical specifications, with the exception of several items discussed under "Design Modifications".

At the October 13, 1993 meeting, attended by representatives of DNREC, STAR, VFL, and DAI, several landfill items were discussed which required completion before DNREC would approve trial operation of Cell No. 1. The following items, not completed at the time of this meeting, have since been completed:

- Permanent fencing has been installed around the entire IWL landfill, including the south pit area. Four vehicular access gates have been provided.
- Bituminous concrete paving of the Cell No. 1 Access Road and placement of the concrete barriers was completed during the week of October 24, 1993.
- STAR has indicated that they have provided DNREC with a copy of the proposed leachate monitoring plan for the Cell No. 1 trial period.

Design Modifications

Several modifications to the approved design plans were made during construction of Cell No. 1. These modifications were made to facilitate construction and do not affect the function of the dual containment requirements of Cell No. 1.

- Relocation of Stormwater Drainage Swale Along Side of Landfill. This modification was made to minimize the amount of excavation of miscellaneous debris materials from a pre-existing disposal area, east of the IWL. These modifications included adjustments to stormwater drainage swale location, perimeter fence location, and the elevations of sewer manholes between the stabilization pad to Manhole 5. These modifications did not impact design of the Cell No. 1 containment area. Copies of the as-built drawings will be provided with a final documentation report following completion of Cell Nos. 1, 2, and 3.

Mr. Michael Harasika
November 2, 1993
Page 3

- Change Order No. 3 - Access Road Revisions. The pavement cross section of the Cells Nos. 1, 2 and 3 access roads was modified. The purpose of this modification was to prevent encroachment of the paved roadway over the 3 horizontal to 1 vertical side slope cover soil. Copies of Change Order No. 3 (Sheets 1, 2, and 3) addressing this modification have been enclosed.
- Change Order No. 4, Pump Station/Collection Sump Revisions. To address concerns from the IWL sump pump manhole manufacturer, over potential "down drag" of the sump pump due to settlement of materials around the manhole, an eight (8) inch layer of clay below the base of the sump pump was added. The purpose of this 8 inch layer of clay is to accommodate possible settlement associated with potential "down drag" of the pump station. Copies of Change Order No. 4 (Sheets 1, 2, 3, 4 and 5) addressing this modification have been enclosed.
- Modification of Drainage Control Berm Between Cells No. 1 and No. 2. This berm was designed to provide a separator between the waste material and leachate generated in Cell No. 1 (active cell) and Cell No. 2 (inactive cell). The project plans specify a drainage control berm constructed of compacted clay material between the adjacent cells. This detail has been revised to specify a berm constructed to the same dimensions indicated on the contract plans and consisting of compacted borrow (e.g. Delaware "Select" Borrow) with a 60 mil HDPE liner installed on the side of the berm in common with Cell No. 1 (active cell). The 60 mil HDPE is to be in contact with the primary liner and provided with an interface of powdered sodium bentonite between the liner and the primary liner. Copies of this detail have been enclosed.
- Temporary Anchor Trench. The contract drawings indicate that the primary and secondary HDPE liners for each active cell will be terminated in a temporary anchor trench at the interface between the active and inactive (or future) cells. However, since the STAR Industrial Waste Landfill double liner system is being constructed in a continuous manner through Cells Nos. 1, 2, and 3, no temporary anchor trench is being provided. To minimize migration of stormwater from the inactive cells into the leachate detection system of Cell No. 1, a temporary seal

Mr. Michael Harasika
November 2, 1993
Page 4

(extrusion weld) has been provided between the primary liner with the secondary liner at the collection trench of Cell No. 2. At completion of the HDPE liner construction for Cells 2 and 3, the temporary seal will be removed. To minimize the potential for stormwater entering the collection system of Cell No. 1, a temporary PVC valve has been provided in Cell No. 2, adjacent to the drainage control berm. At this location, a solid wall HDPE leachate pipe has been substituted for the specified slotted leachate collection pipe at the valve. This area has been backfilled with clay material to provide a "plug" restricting stormwater generated in Cells 2 and 3 from entering the Cell No. 1 area. The stormwater collected in the sump created at the valve area will be "control fed" by STAR into the leachate collection system and wastewater treatment plant or pumped (by a temporary pump) directly into the IWL perimeter stormwater collection system. The PVC valve will be removed and replaced with slotted pipe at the time Cell 2 is put into active use (and similarly, Cell 3). Details of the valve and sump areas will be provided on the final as-built drawings.

Temporary Facilities for Trial Operation

Several construction items remain to be completed prior to final acceptance of Cell 1. However, temporary facilities have been installed to allow trial operation of Cell 1, which should not impact the function of the dual containment landfill. These items were discussed at the DNREC meeting of October 13, 1993. The items that remain to be completed, along with scheduled completion dates, and temporary facilities are discussed in the following paragraphs:

- Drainage Control Berm Between Cell No. 1 and Cell No. 2. The drainage control berm is in place across the bottom (base) of the cell. This should provide an effective containment of the Cell No. 1 area during the trial operation period. Construction of the berm, in accordance to the project plans, on the side slopes of the landfill, is ongoing. VFL stated that this construction of the Cell No. 1 berms on the side slopes will be completed by December 1, 1993.
- Clay Run-On Control Berm. This two (2) foot high clay berm is located around the perimeter of the landfill. The presence of this berm should not impact the ability of Cell No. 1 to accept waste.

Mr. Michael Harasika
November 2, 1993
Page 5

The contractor has placed the initial approximate one (1) foot lift of clay over the perimeter of the Cell No. 1 area and is presently "conditioning" this material. Construction of the clay "test strip" is scheduled for the week of November 1, 1993. Following construction, acceptance and approval of the test strip, the clay run-on control berm should be constructed in accordance with the project plans. VFL indicated that this construction will be completed by December 17, 1993.

- Pump Station. The base section of the IWL pump station and the collection/detection piping is in place. However, the contractor is still awaiting delivery of the control panels for the electrical/mechanical pumping system. A temporary pumping system has been installed, and will be operated until the permanent system is completed. This temporary system includes pumps and flow meters for both the detection and collection systems. It is our understanding that the flow meters will be monitored on a weekly basis by VFL during the trial operation period. A letter from VFL providing the details of the temporary leachate detection system and leachate collection system facilities has been enclosed. VFL has stated that the permanent collection/detection system will be installed by December 1, 1993.
- Connection of the leachate dual piping system from the IWL pump station to Manhole 5 has not been completed. VFL indicated that this system will be placed in-line, with the permanent collection/detection controls by December 1, 1993.
- Manhole No. 5 was constructed in accordance with plans and details provided by STAR. This manhole collects run-off from the stabilization pad, the IWL collection system pump station and the leachate detection system. The plans indicated that two (2) pumps at Manhole No.5 will pump the collected leachate and run-off from the facilities to STAR's wastewater treatment plant. VFL has indicated that these pumps will be connected, following installation of the control panels, by December 1, 1993. The enclosed VFL letter details the temporary pumps to be utilized in Manhole 5 until completion of the final installation.

Mr. Michael Harasika
November 2, 1993
Page 6

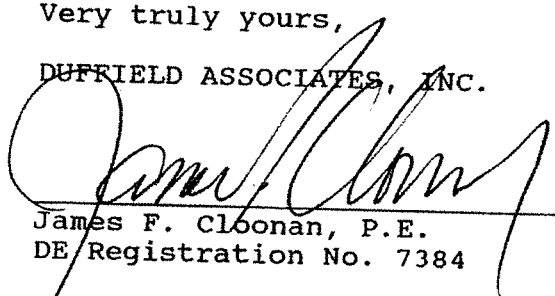
Duffield Associates, Inc. "certifies", with the exceptions noted herein, that Cell No. 1 of the dual containment Star Industrial Waste Landfill of the Delaware City refinery has generally been constructed in accordance with the contract plans and technical specifications and Construction Quality Assurance/Quality Control (CQA/QC) Plans as prepared by Duffield Associates, Inc. The term "certifies", as utilized herein, means "to state or declare a professional opinion as CQA officer, based on our review of the available information". "Certifies" does not mean or imply a guarantee by the CQA Officer (DAI), nor does the CQA officer's certification relieve any other party from meeting the requirements imposed by contract and the project contract documents including the plans, technical specifications, and CQA/QC Plan.

Based on our field observations and review of available data, and in accordance with the schedule provided for completion of the outstanding items, it is our opinion that a trial operation, including disposal of Fly Ash materials in Cell No. 1, can proceed.

If you have any questions or comments concerning the enclosed, or require any further information, please do not hesitate to contact us.

Very truly yours,

DUFFIELD ASSOCIATES, INC.



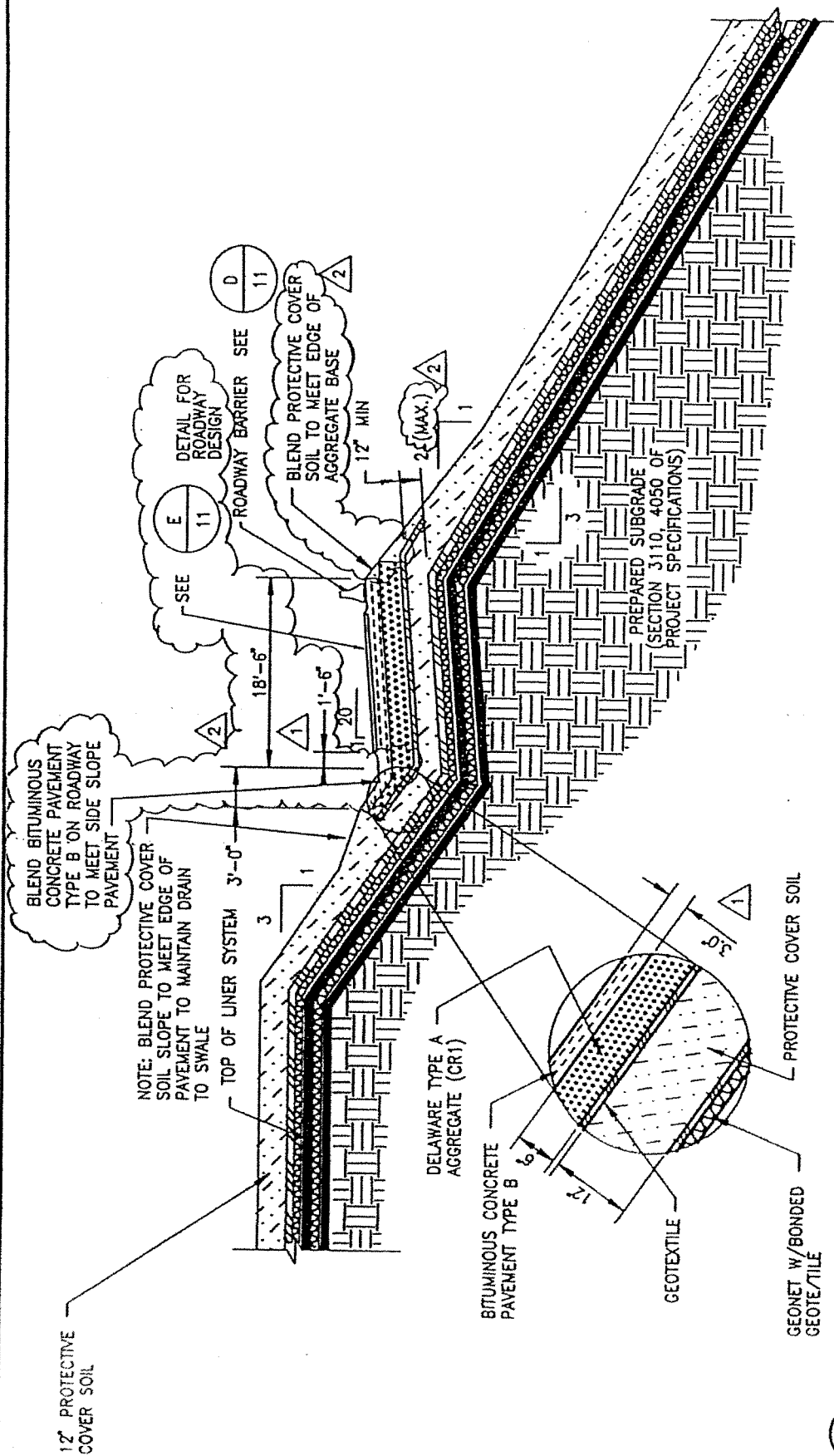
James F. Cloonan, P.E.
DE Registration No. 7384

Construction Quality
Assurance Officer

JFC:has
JFC21:1867NK-2.LTR

Enclosures: Change Order No. 3 Details
Change Order No. 4 Details
Drainage Control Berm Modification Details
VFL Letter - October 25, 1993

cc: Mr. David Martin - VFL Technology Corporation
Mr. Jeffrey M. Bross, P.E. - Duffield Associates, Inc.



ACCESS ROAD TYPICAL CROSS SECTION

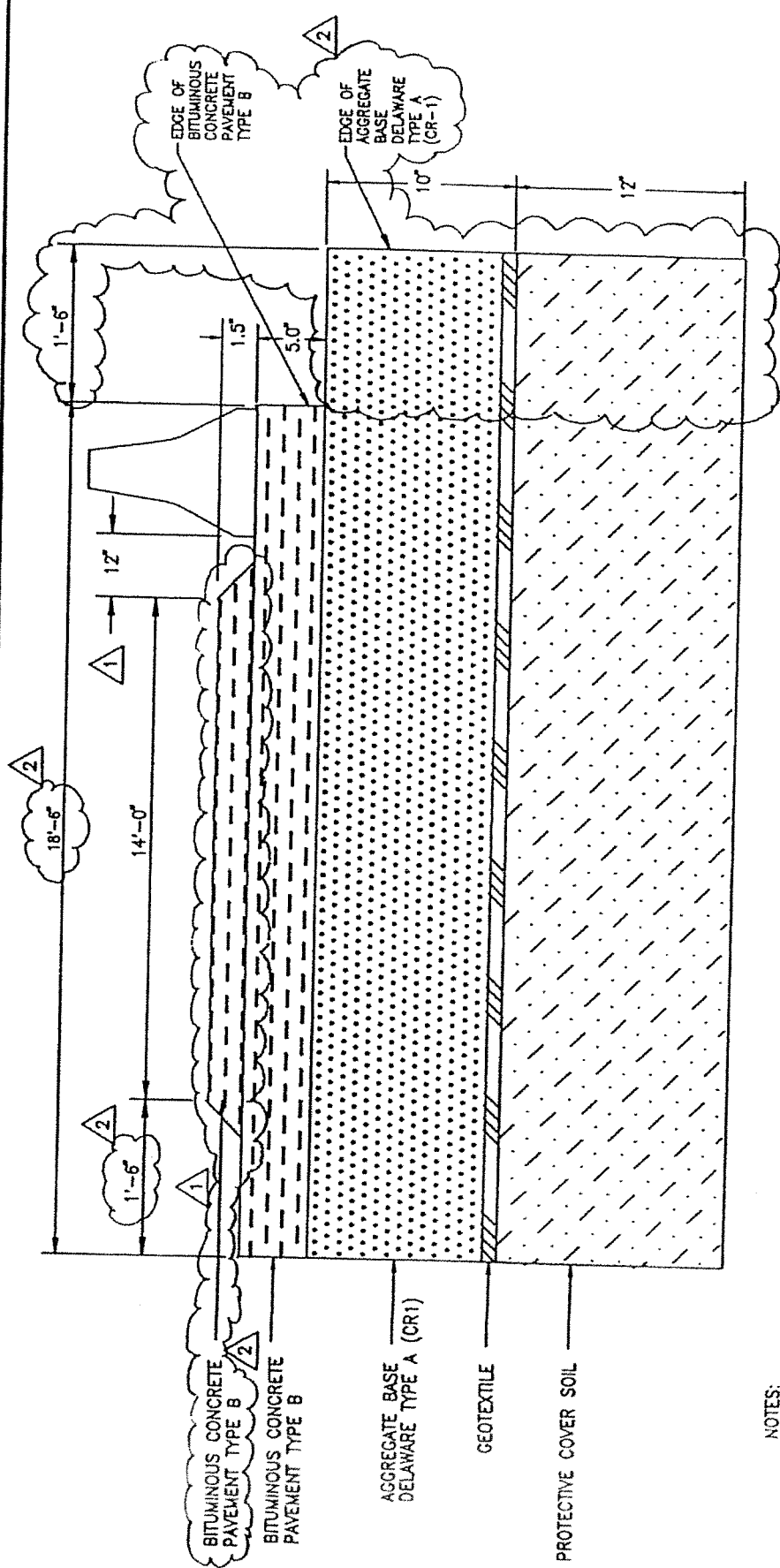
NOTES: 1. CLAY/GEOSYNTHETIC COMPOSITE SHALL BE INSTALLED BENEATH THE SECONDARY GEOMEMBRANE WHERE THE ROAD SLOPE INTERSECTS THE LANDFILL BOTTOM. SEE 11 OF SHEET 11 OF 18, DATED MARCH 1992, LAST REVISION: SEPTEMBER 15, 1992.

DUFFIELD ASSOCIATES, INC.
CONSULTANTS IN THE GEOSCIENCES
WILMINGTON, DELAWARE ELKTON, MARYLAND

CHANGE ORDER NO. 3 - ACCESS ROAD REVISIONS
STAR INDUSTRIAL WASTE LANDFILL
NEW CASTLE COUNTY, DELAWARE

Drawn: DSH	Chk'd: NONE	Date: 7 SEPTEMBER 1993
Scale:		W.O.: 1867/EA
File No: A-1867EA-1	Sheet: 1	of 3
Rev. No:	Revision:	Date:

Approved By:



NOTES:

1. MATERIALS AND CONSTRUCTION SHALL CONFORM TO DELDOT STANDARD SPECIFICATIONS, LATEST EDITION.
2. EXTEND GEOTEXTILE AT MINIMUM OF 3 FEET BEYOND EDGE OF ROAD.
3. WHERE RAMP CROSSES CLAY RUN ON CONTROL BERM, FULL DEPTH ROAD SECTION (28.5") REPLACES RUN ON CONTROL BERM. SEE (F) 11
4. THIS DRAWING REPRESENTS THE ACCESS ROAD REVISIONS TO DETAIL (E) OF SHEET 11 OF 18, DATED MARCH 1992, LAST REVISION: SEPTEMBER 15, 1992.

(E) 11

ACCESS ROAD BED CROSS SECTION

DUFFIELD ASSOCIATES, INC.
CONSULTANTS IN THE GEOSCIENCES
WILMINGTON, DELAWARE ELKTON, MARYLAND

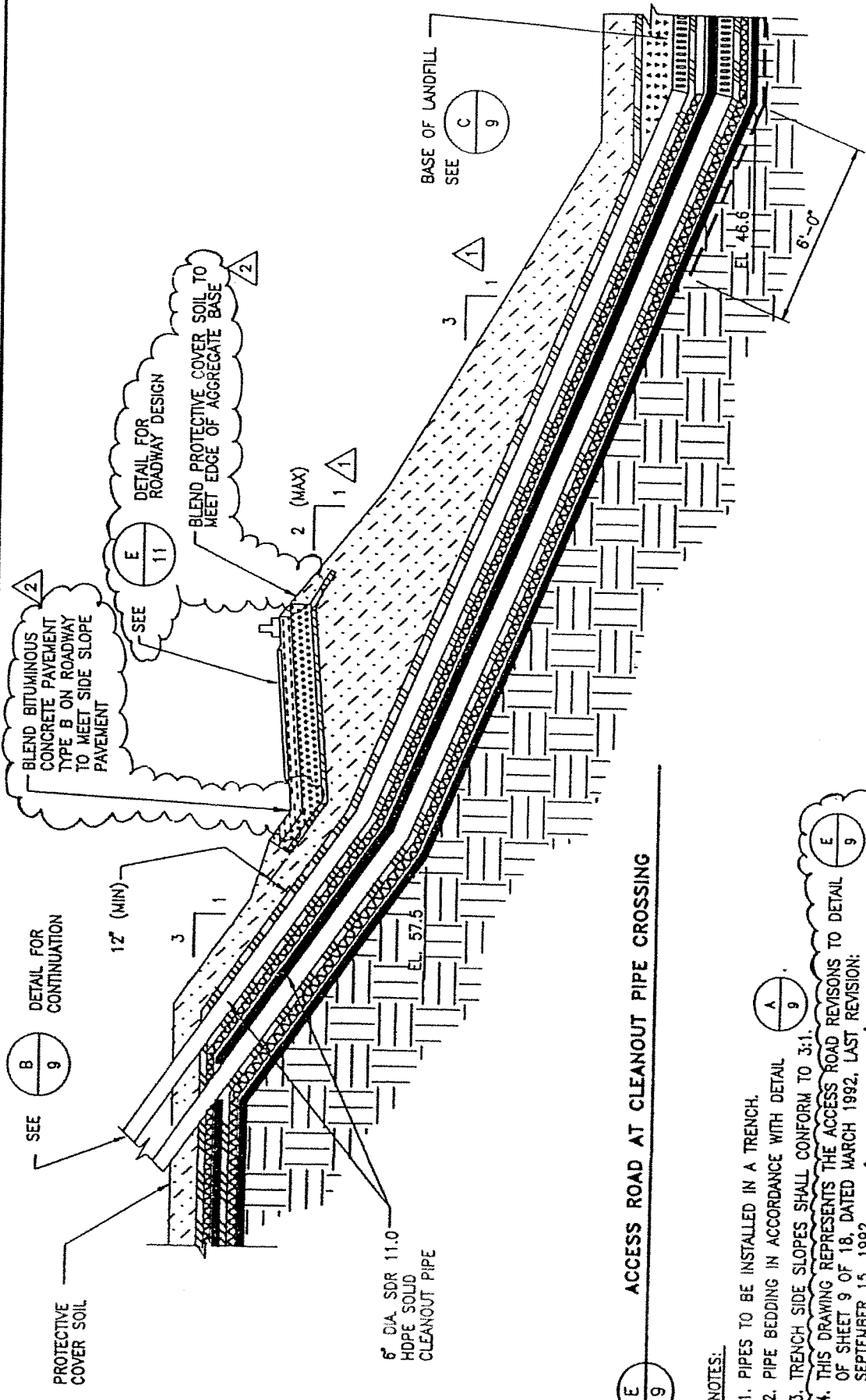
CHANGE ORDER NO. 3 -- ACCESS ROAD REVISIONS

STAR INDUSTRIAL WASTE LANDFILL

NEW CASTLE COUNTY, DELAWARE

Drawn: DSH	Chk'd: [Signature]	Date: 7 SEPTEMBER 1993
Scale:	NONE	W.O.: 1867.EA
File No: A-1867EA-2	Sheet: 2 of 3	Date:
Rev. No:	Revision:	

red By:



ACCESS ROAD AT CLEANOUT PIPE CROSSING

NOTES:

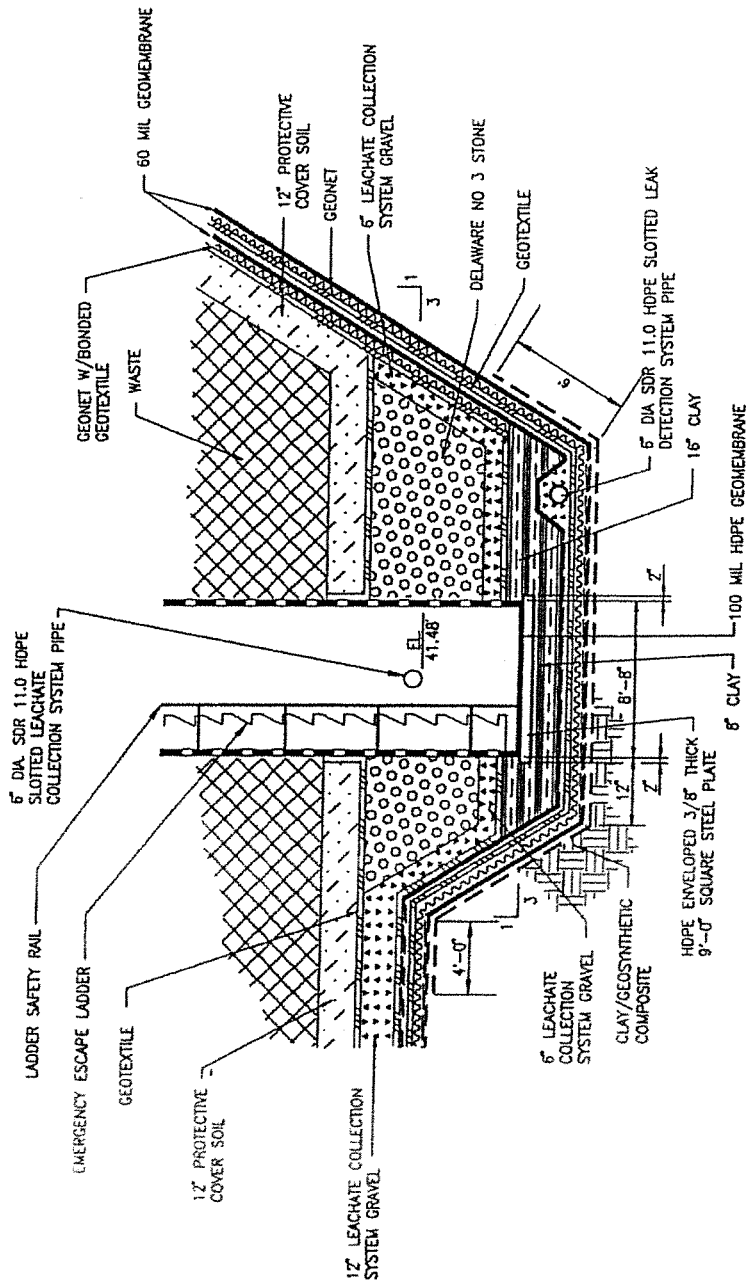
1. PIPES TO BE INSTALLED IN A TRENCH.
2. PIPE BEDDING IN ACCORDANCE WITH DETAIL **B/9**.
3. TRENCH SIDE SLOPES SHALL CONFORM TO 3:1.
4. THIS DRAWING REPRESENTS THE ACCESS ROAD REVISIONS TO DETAIL OF SHEET 9 OF 18, DATED MARCH 1992, LAST REVISION: SEPTEMBER 15, 1992.

DUFFIELD ASSOCIATES, INC.
 CONSULTANTS IN THE GEOSCIENCES
 WILMINGTON, DELAWARE ELKTON, MARYLAND

CHANGE ORDER NO. 3 - ACCESS ROAD REVISIONS
STAR INDUSTRIAL WASTE LANDFILL
 NEW CASTLE COUNTY, DELAWARE

Drawn: DSH	Chk'd: NONE	Date: 7 SEPTEMBER 1993
Scale:	W.O.:	1867.EA
File No: A-1867EA-3	Sheet: 3 of 3	Date:
Rev. No:	Revision:	

ed By:



A PUMP STATION COLLECTION SUMP NORTH-SOUTH SECTION

12

NOTES:

1. 3/8" THICK STEEL PLATE (9'-0" x 9'-0") SHALL BE GALVANIZED AND COVERED ON EACH SIDE WITH 100MIL HDPE, EXTRUSION OR FUSION WELDED AT THE SEAMS, TO COMPLETELY SEAL THE STEEL PLATE.
2. AN ADDITIONAL MINIMUM 100MIL HDPE MEMBRANE SHOULD BE WELDED TO BOTTOM OF PUMP STATION MANHOLE.
3. CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING THE PUMP STATION MANHOLE LOCATION ON THE STEEL PLATE, ± 1 INCH TOLERANCE, DURING BACKFILL ACTIVITIES.
4. CONTRACTOR SHALL BE RESPONSIBLE FOR SECURING A GEOTEXTILE 12 INCHES IN LENGTH BETWEEN PROTECTIVE COVER SOIL AND PUMP STATION AROUND THE PERIMETER OF THE PUMP STATION.

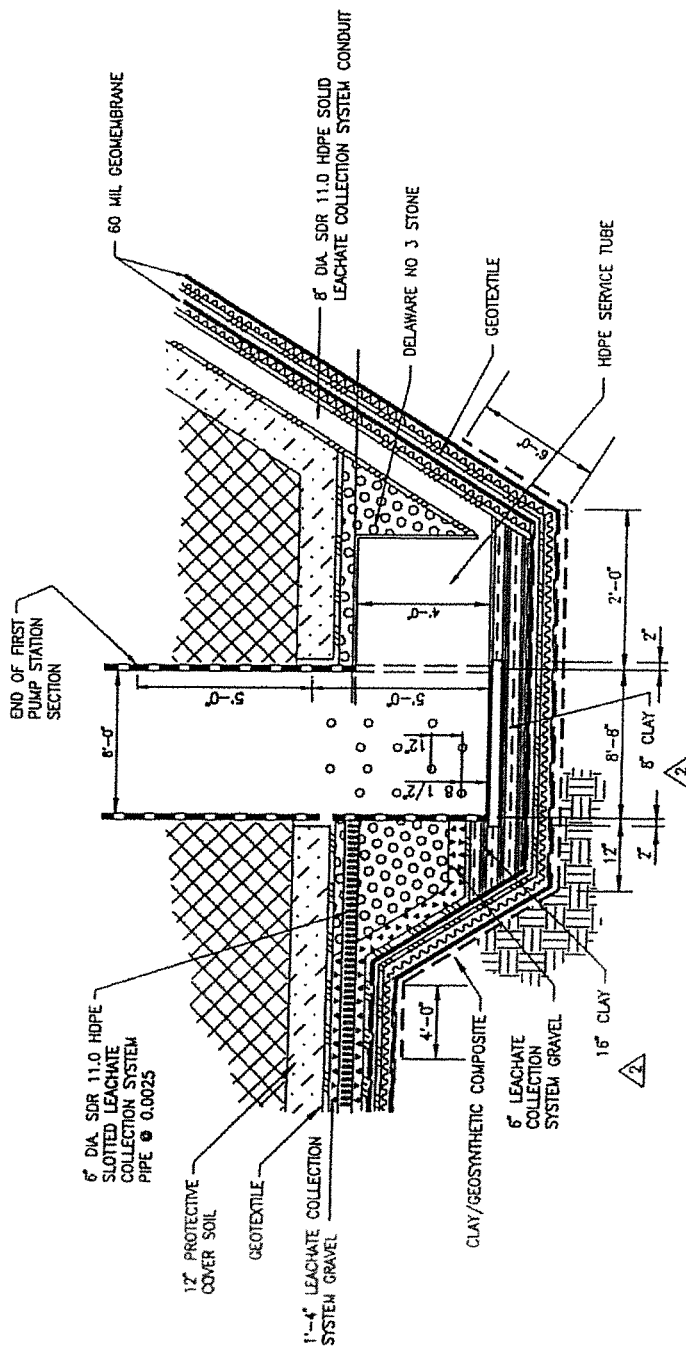
CHANGE ORDER NO. 4
PUMP STATION/COLLECTION SUMP REVISIONS
STAR INDUSTRIAL WASTE LANDFILL
NEW CASTLE COUNTY - DELAWARE



DUFFIELD ASSOCIATES, INC.
CONSULTANTS IN THE GEOSCIENCES
WILMINGTON, DELAWARE ELKTON, MARYLAND

DESIGNED BY	LDC	DATE	9 SEPTEMBER 1993
DRAWN BY	DSH	SCALE	NONE
CHECKED BY	JF	W.O. NO.	1867EA
DRAWING NO.	9-1867EA-1		FIGURE 1

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PUMP STATION COLLECTION SUMP EAST-WEST SECTION

NOTES:

1. THE FIRST ROW OF PUMP STATION PERFORATIONS IS CENTERED AT A HEIGHT OF 8 1/2' ABOVE THE BOTTOM OF THE LOWEST PUMP STATION SECTION. HOLES ARE 1" DIA., SPACED 30" APART FOR A TOTAL OF 12 HOLES PER ROW. EACH SUBSEQUENT ROW IS SPACED 12" ABOVE THE LOWER ROW. HOLE PATTERN ROTATES 15° WITH EACH ROW.
2. FOR INFORMATION NOT SHOWN, SEE

A
12

B
12

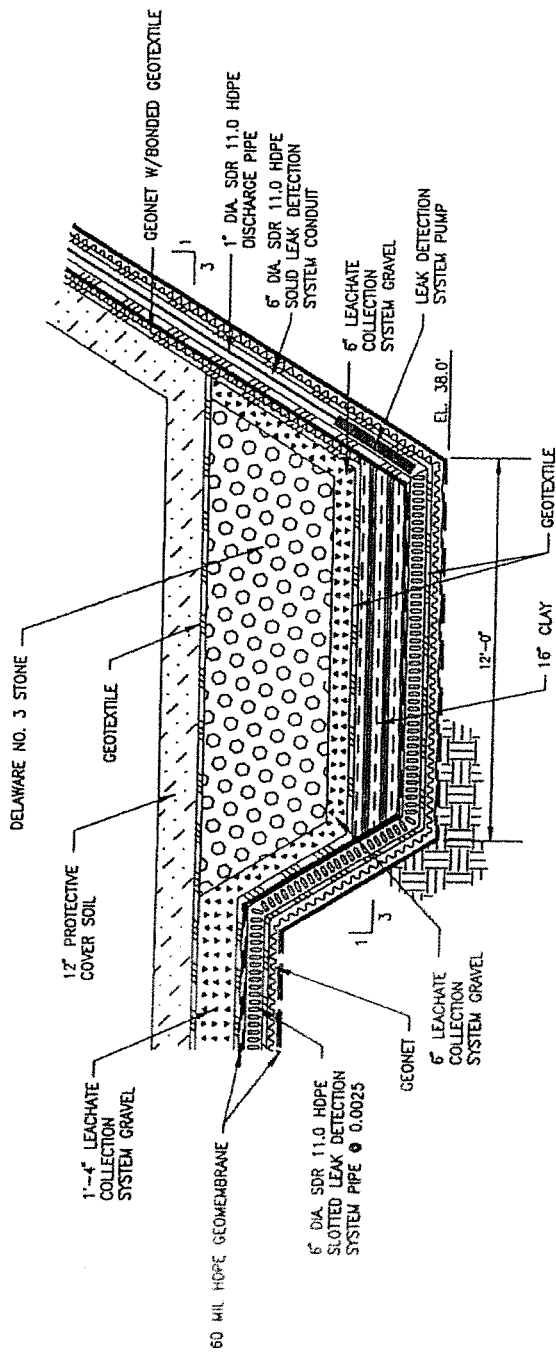
CHANGE ORDER NO. 4
PUMP STATION/COLLECTION SUMP REVISIONS
STAR INDUSTRIAL WASTE LANDFILL
NEW CASTLE COUNTY - DELAWARE



DUFFIELD ASSOCIATES, INC.
CONSULTANTS IN THE GEOSCIENCES
WILMINGTON, DELAWARE ELKTON, MARYLAND

DESIGNED BY	LDC	DATE	9 SEPTEMBER 1993
DRAWN BY	DSH	SCALE	NONE
CHECKED BY	[Signature]	W.D. NO.	1867 EA
DRAWING NO.	8-1867EA-2	FIGURE 2	

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C LEAK DETECTION SYSTEM SUMP EAST-WEST SECTION

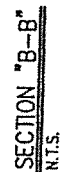
CHANGE ORDER NO. 4
 PUMP STATION/COLLECTION SUMP REVISIONS
 STAR INDUSTRIAL WASTE LANDFILL
 NEW CASTLE COUNTY - DELAWARE

DUFFIELD ASSOCIATES, INC.
 CONSULTANTS IN THE GEOSCIENCES
 WILMINGTON, DELAWARE ELKTON, MARYLAND

DESIGNED BY	LDC	DATE	9 SEPTEMBER 1993
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CHECKED BY	<i>[Signature]</i>	W.O. NO.	1867.EA
DRAWING NO.	B-1867EA-3		

FIGURE 3

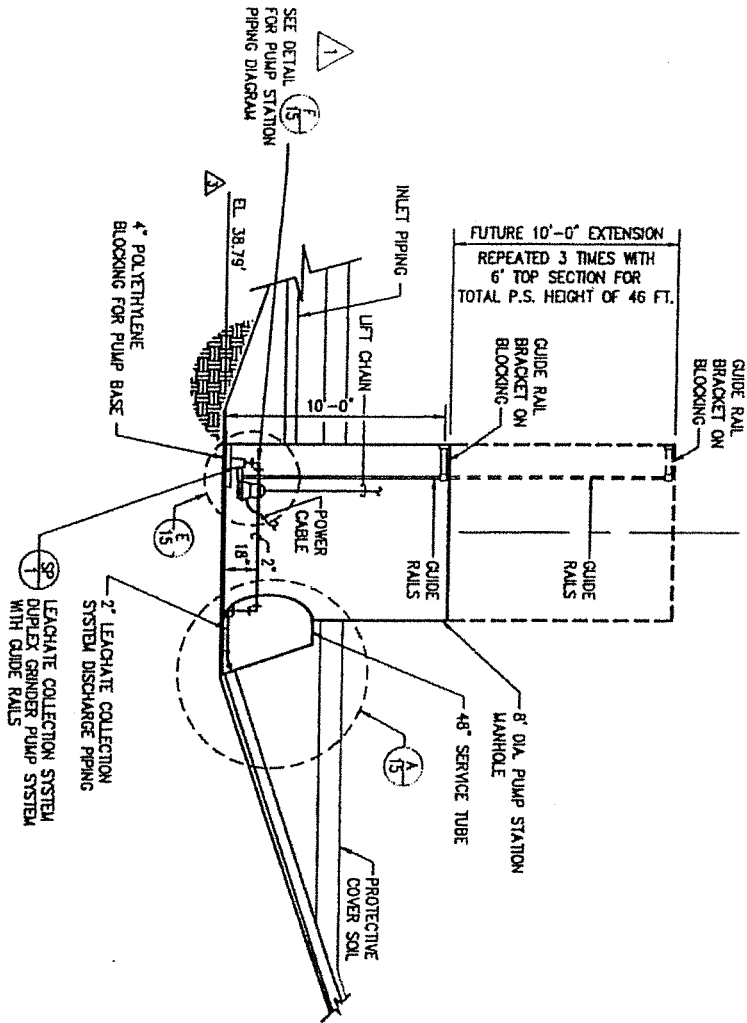
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DUFFIELD ASSOCIATES, INC.
CONSULTANTS IN THE GEOSCIENCES
WILMINGTON, DELAWARE ELKTON, MARYLAND

DESIGNED BY	LOC	DATE	9 SEPTEMBER 1993
DRAWN BY	DSH	SCALE	NONE
CHECKED BY	<i>[Signature]</i>	W.O. NO.	1867EA
DRAWING NO.	B-1867EA-4		5707 LOC 4

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CHANGE ORDER NO. 4
PUMP STATION/COLLECTION SUMP REVISIONS
STAR INDUSTRIAL WASTE LANDFILL
NEW CASTLE COUNTY - DELAWARE



DUFFIELD ASSOCIATES, INC.
CONSULTANTS IN THE GEOSCIENCES
WILMINGTON, DELAWARE ELKTON, MARYLAND

DESIGNED BY	LDC	DATE	9 SEPTEMBER 1993
DRAWN BY	DSH	SCALE	NONE
CHECKED BY	YPC	W.O. NO.	1867EA
DRAWING NO.	B-1867EA-5	FIGURE	5

SECTION 02200

EARTHWORK

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. General
- B. Excavation
- C. Management of Unsuitable Subgrade Materials
- D. Management of Debris
- E. Daily Cover Materials
- F. Interim Grading Soil Buffer Materials
- G. Stockpiling
- H. Fill and Backfill
- I. Channels or Ditches
- J. Site Grading
- K. Drainage and Dewatering

1.2 RELATED SECTIONS

- A. Section 01050 - Field Engineering and Surveying
- B. Section 01300 - Submittals
- C. Section 01390 - Preparation of a Health and Safety Plan
- D. Section 01400 - Quality Control and Quality Assurance
- E. Section 02100 - Site Preparation
- F. Section 02205 - Soil Materials

- G. Section 02207 - Aggregate Materials
- H. Section 02270 - Soil Erosion and Sediment Control Measures

1.3 MEASUREMENT AND PAYMENT

- A. Excavation and Backfilling of On-Site Soil and Waste Materials Inside Landfill Limits: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes excavating, loading, hauling, moisture-adjusting (e.g., wetting, scarifying), grading, placing and compacting on-site soil and waste materials to achieve site preparatory grades. Materials excavated within the limits of landfill wastes and installed as compacted fill, as accepted by the Construction Manager, will be paid for on a fixed unit price basis in accordance with the Bid Schedule.
- B. Excavate, Haul and Place Off-site Subgrade Borrow from Source on the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes excavation, loading, hauling, stockpiling, moisture-adjusting (e.g., wetting, scarifying), placement, grading and compaction as needed to achieve site preparatory grades. Off-site subgrade borrow installed as accepted by the Construction Manager, will be paid for on a fixed unit price basis in accordance with the Bid Schedule.
- C. Furnish and Place Off-Site Subgrade Borrow From Source Outside the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes furnishing, moisture-adjusting, placement, grading and compaction as needed to achieve site preparatory grades. Off-site, off-property subgrade borrow installed and accepted by the Construction Manager will be paid for on a fixed unit price basis in accordance with the Bid Schedule.
- D. Excavate, Haul and Place Off-site Daily Cover Materials From Source on the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes excavation, loading, hauling, stock-piling, moisture-adjusting, placement and compaction of daily cover material. Daily cover material installed and accepted by the Construction Manager will be paid for on a fixed unit price basis in accordance with the Bid Schedule.
- E. Excavate, Haul and Place Off-site Daily Cover Materials From Source Outside the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes excavation, loading, hauling, stock-piling, moisture-adjusting, placement and compaction of daily cover material. Daily cover material installed and accepted by the Construction Manager will be paid for on a fixed unit price basis in accordance with the Bid Schedule.

- F. Excavate, Haul and Place Off-site Interim Grading Soil Buffer Material From Source on the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard.. Includes excavation, loading, hauling, stock-piling, moisture-adjusting, placement and compaction of interim grading soil buffer material. Interim grading soil buffer material installed and accepted by the Construction Manager will be paid for on a fixed unit price basis in accordance with the Bid Schedule.
- G. Excavate, Haul, and Place Off-Site Interim Grading Soil Buffer Material From Source Outside the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes furnishing, moisture adjusting, placement, grading and compaction of interim grading soil buffer material. Off-site source from outside the Owner's property will only be used if problems with or limited amounts of borrow from on-property borrow source are encountered, as determined by the Construction Manager. Interim grading soil buffer material installed as accepted by the Construction Manager, will be paid for on a fixed unit price in accordance with the Bid Schedule.
- H. Excavate, Haul and Place Off-Site Protective Cover Soil (Vegetative Soil Cover Material) from Source on the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard.. Includes excavation, loading, hauling, stockpiling, moisture-adjusting (e.g., wetting, scarifying), placement, grading and compaction of protective cover soil (vegetative soil cover material). Protective cover soil installed as accepted by the Construction Manager, will be paid for on a fixed unit price basis in accordance with the Bid Schedule.
- I. Excavate, Haul, and Place Off-Site Protective Cover Soil (Vegetative Soil Cover Material) from Source Outside the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes furnishing, stockpiling, moisture-adjusting (e.g., wetting, scarifying), placement, grading and compaction of protective cover soil (vegetative soil cover material). Off-site source from outside the Owner's property will only be used if problems with or limited amounts of borrow from on property borrow source are encountered as determined by the Construction Manager. Protective cover soil installed, as accepted by the Construction Manager, will be paid for on a fixed unit price in accordance with the Bid Schedule.
- J. Excavate, Haul and Place Off-site Topsoil from Source on the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes furnishing, stockpiling, moisture-adjusting (e.g. wetting, scarifying), amending with nutrients, placement, grading, and compaction, as needed. Topsoil installed, as accepted by the Construction Manager will be paid for on a fixed unit price basis in accordance with the Bid Schedule.

- K. Excavate, Haul, and Place Off-site Topsoil from Source Outside the Owner's Property: On a fixed unit price basis by the in-place, compacted, cubic yard. Includes furnishing, stockpiling, moisture-adjusting (e.g. wetting, scarifying), amending with nutrients, placement, grading, and compaction, as needed. Topsoil installed, as accepted by the Construction Manager, will be paid for on a fixed unit price basis in accordance with the Bid Schedule.
- L. Unsuitable Material Disposal: Lump Sum. Includes disposal of non-hazardous materials deemed unsuitable for use as on-site fill material or for on-site disposal. Unsuitable material disposal will be paid for in accordance with Section 02100, Part 1.3, Paragraph F. and G., as determined and approved by the Construction Manager.

1.4 REFERENCES

- A. ASTM D 698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort
- B. ASTM D 1556 - Density of Soil in Place by the Sand-Cone Method
- C. ASTM D 2167 - Density and Unit Weight of Soil in Place by the Rubber Balloon Method
- D. ASTM D 2487 - Classification of Soils for Engineering Purposes
- E. ASTM D 2922 - Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- F. ASTM D 3017 - Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.5 SUBMITTALS

- A. Submit with Bid the name, address, and qualifications of the independent geotechnical testing firm for approval by the Construction Manager.
- B. Submit a construction work plan with Bid, for Construction Manager review and comment, which includes a description of the soils and materials handling approach proposed by the Contractor. This plan is intended to provide for a mutual understanding between the Owner, Contractor, and Construction Manager, regarding the manner in which materials will be excavated, managed, and placed as on-site compacted fill, and unsuitable materials will be placed at specified on-site locations within the landfill. At a minimum, the soils and materials handling

plan shall address the following with respect to achieving landfill preparatory grades and stormwater channel and basin (if any) subgrades.

1. Locations and sequence of excavation of and filling with on-site soil materials.
 2. Anticipated locations, quantities, and planned use(s) of stockpiled soil materials furnished from off-site locations.
 3. Locations and sequence of placement of off-site soil materials suitable for use as compacted fill.
 4. Locations, methods, and sequence of placement of stumps (if any) and oversized soil materials within the landfill (at least 24 inches below preparatory grades).
 5. Locations, methods, and sequence of placement of demolition debris (if any) outside the horizontal limits of the landfill as directed by the Construction Manager.
 6. Equipment anticipated for use in excavating and transporting on-site soils.
 7. Locations of anticipated temporary access roads.
 8. Dewatering procedures.
- C. Within 2 weeks of Contract Award, submit to the Construction Manager for approval the name and address of alternative off-site, off-property soil borrow sources, unless otherwise identified by the Owner.
- D. Submit the following to the Construction Manager regarding on-site excavations:
1. Survey information sufficient to determine the in-place (in the cut) yardage of all excavations.
 2. The original and final locations of excavated landfill materials, if any, recorded on as-built drawings.
- E. Surveys: In accordance with Section 01050, submit as-built drawings (showing one-foot contour intervals) for Construction Manager review and approval at the following project milestones:
1. At the beginning of the project prior to any site grading.

2. At the completion of excavation and filling of on-site waste/soil, immediately prior to placement of a temporary synthetic cover geomembrane
3. At the completion of protective cover soil placement. Topsoil shall not be placed until the Construction Manager has approved the protective cover soil as-built survey information.
4. Final grade following topsoil placement.

As-built drawings shall be prepared and submitted as areas of soil placement are completed so as to not delay the Work. Each surveyed surface shall not be covered until the as-built survey for said surface has been submitted to, reviewed and approved by the Construction Manager in writing. The Contractor shall allow a minimum 7 days for each as-built review.

- F. Material Testing: Provide tests in accordance with Section 02205, Part 4.
- G. Certifications: At least 7 days prior to delivery, provide Certifications of Compliance for all non-waste materials provided.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

- A. Provide soil materials in accordance with Section 02205, Part 2.

2.2 EROSION AND SEDIMENT CONTROL MATERIALS

- A. Provide erosion and sediment control materials in accordance with Section 02270, Part 2.

PART 3 EXECUTION

3.1 GENERAL

- A. All earthwork shall be done in a manner protective of the existing landfill liner system, all installed landfill control systems, and groundwater monitoring wells.

3.2 EXCAVATION

- A. All excavation shall be unclassified. Excavation of all material encountered shall be carried out to the lines and grades indicated on the Drawings and/or details, as specified, or as directed by the Construction Manager. Stumps, buried logs, roots, rootmass, debris and other materials unsuitable for controlled fill shall be managed in accordance with Section 02100 of these Specifications.
- B. All excavations carried below the depths indicated, without specific directions from the Construction Manager, shall be refilled and compacted to the proper grade with suitable material at no cost to the Owner.
- C. Excavations shall be kept stable and free from water while construction therein is in progress. All work shall be performed to minimize stormwater ponding on or within landfill waste materials. Any water that has come into contact with or is believed to have come in contact with waste materials shall not be allowed to move beyond the landfill's limit of waste. The Contractor shall manage such water and pump it to the Refinery wastewater treatment plant at no cost to the Owner. All pumping of water to the Refinery wastewater treatment plant shall be coordinated with and approved by the Refinery (Premcor).
- D. Remove soil material delivered from off-site locations back to its borrow source that does not meet the requirements for completing its intended use in the Work, at no cost to the Owner. Soil materials delivered to the site with excessive moisture content, as indicated in Part 1.3, shall also be removed unless otherwise approved by the Construction Manager.
- E. The Contractor shall exercise caution when working in areas containing utilities. The completeness or accuracy of the information presented on the Drawings is not guaranteed. No claim shall result against the Owner or Construction Manager as a result of unforeseen subsurface conditions. The Contractor is responsible for locating all subsurface utilities before start of Work.
- F. On-site subgrade material (landfill fill and soils) shall be excavated, loaded, hauled, placed, compacted, graded and accepted to achieve landfill preparatory grades prior to bringing (if required) off-site subgrade borrow onto the site, unless otherwise approved by the Construction Manager.
- G. Excavation and grading for preparatory grading will proceed to elevations and dimensions shown on the Drawings, and shall be within the tolerances specified herein.
- H. The Contractor shall plan and control the placement of unsuitable excavated fill materials (e.g., waste and materials containing oversized particles). This material

shall be properly placed no less than 36 inches below preparatory grades within the landfill.

3.3 MANAGEMENT OF UNSUITABLE SUBGRADE MATERIALS

- A. Certain excavated, on-site soil or waste materials may be unsuitable as subgrade fill by nature of their composition. Excessive moisture content shall not render excavated soils unsuitable, unless allowed otherwise by the Construction Manager. Unsuitable excavated materials contain excessive particle sizes, excessive organic content or matter (e.g., root mass, buried stumps or logs, etc.), excessive deleterious material or which otherwise do not satisfy the subgrade material requirements specified in Section 02205.
- B. Excavated materials unsuitable as subgrade material shall be placed in the deepest fill areas of the landfill and covered with a minimum of 36 inches of suitable subgrade material.
- C. Excavated materials (including screened oversized particles) which contain excessive particle size, and for which processing to render them suitable is not practicable, shall be placed in a controlled manner at the base of the subgrade layer and within the deepest fill portions of the subgrade. At no location shall materials of excessive particle size be located within 36 inches of the geomembrane barrier layer. Oversized particles shall be placed flat and their voids in-filled with suitable subgrade fill soil to prevent movement and 'cardhousing' of materials. The in-filled particles shall be compacted with a heavy-duty, smooth-drum roller with vibratory capability until observed to be dense and stable by the Construction Manager. If the Construction Manager deems the in-filled material to not be stable or subject to localized settlements, the Contractor shall excavate, re-work and compact the material. The Construction Manager may require the placement of a geotextile atop the in-filled material to 'bridge' potential settlement areas.

3.4 MANAGEMENT OF DEBRIS

- A. Inert debris shall be placed outside the horizontal limits of the landfill as directed by the Construction Manager. See Section 02100 for additional requirements.

3.5 DAILY COVER MATERIALS

- A. Daily cover materials shall be placed to cover landfill waste materials exposed in conjunction with site excavations and grading.

- B. Daily cover material shall consist of material satisfying the landfill operations plan and permit, as approved by the Construction Manager. Daily cover material shall be placed daily on top of exposed waste material to prevent the transport of contaminants beyond the limit of landfill wastes. Daily cover material shall be placed at the end of each day's work in a manner that completely covers exposed landfill materials with a minimum thickness of 6 inches and prevents stormwater contact with or ponding above landfill materials.

3.6 INTERIM GRADING SOIL BUFFER MATERIALS

- A. Interim grading soil buffer shall consist of a predominantly medium to high plasticity clay imported from a local borrow source and be placed along the perimeter of the IWL as shown on the Drawings.

3.7 STOCKPILING

- A. No materials shall be stockpiled at the site without approval of the Construction Manager. If, at the time of on-site excavation, it is not possible to place material in its proper location of permanent construction, it shall be temporarily stockpiled and maintained in previously approved areas for later use. Stockpile excavated on-site or off-site materials as necessary in locations approved by the Construction Manager and in a manner that will not erode or cause sedimentation.
- B. The Contractor is solely responsible for delivery of off-site soil material that cannot be immediately placed and does not have prior approval for stockpiling. Such material shall be sent off site until time for placement at no cost to the Owner.
- C. At a minimum, separate stockpiles may be required for each of the following types of off-site materials:
 - 1. Subgrade material
 - 2. Interim cover soil
 - 3. Protective soil cover
 - 4. Topsoil
- D. Prevent intermixing of soil types or contamination. Separate from the supporting foundation material with geotextile or other approved material.
- E. Direct surface water away from stockpile sites to prevent saturation, erosion, particle segregation, or deterioration of materials. Install sediment controls (e.g., silt fence) down gradient of stockpile sites to minimize sediment migration.
- F. The Contractor shall maintain all stockpiles in a safe and controlled manner during their use, including implementation of measures to minimize erosion and

clean-up of any on-site sedimentation determined by the Construction Manager to have been created by the stockpile. Stockpiles shall not impede existing or constructed surface drainage patterns.

- G. The Contractor shall not stockpile materials in areas containing utilities. The completeness or accuracy of the information presented on the Drawings is not guaranteed. No claim shall result against the Owner or Construction Manager as a result of unforeseen subsurface conditions. The Contractor is responsible for locating all subsurface utilities before start of Work.
- H. Remove any unused stockpiles and leave stockpile areas in a clean and neat condition at the completion of earthwork. Grade site surface to prevent free standing surface water.

3.8 FILL AND BACKFILL

A. General

1. Prior to placing fill or backfill material, all off-site soils to be used for construction shall be tested by an approved geotechnical laboratory, as specified in Section 02205, Part 4 as appropriate. Materials must be approved by the Construction Manager prior to their use.
2. Areas to receive fill or backfill materials shall be first cleared and grubbed as specified in Section 02100 and all excavation activities shall be complete.
3. The Contractor shall not place materials in areas of standing water. The Contractor shall keep all areas of construction dewatered.
4. Frozen materials shall not be placed as fill or backfill, nor shall materials be placed on frozen subgrade.
5. Areas designated to receive fill or backfill shall be graded to remove surface irregularities.
6. Regraded soil and waste, fill and backfill shall be placed in approximately horizontal layers, except on fill side slopes, where material shall be placed parallel to the proposed side slope. The thickness of each layer shall not exceed 8 inches before compaction, unless otherwise stated in these Specifications or approved by the Construction Manager. Hand-compacted fill, including fill compacted by manually-directed power tampers, shall be placed in layers not exceeding 4 inches before compaction. In all areas, fill shall be placed 3 inches higher than the final grade, then trimmed to provide a continuous, smooth, compacted surface.

7. Thorough compaction shall be obtained by multiple coverages of appropriate compaction equipment over successive lifts to obtain uniform and adequate density and stability.
8. The Contractor shall engage an approved independent geotechnical testing firm to monitor earthworks quality, in accordance with Section 01400, unless otherwise approved by the Construction Manager.
9. The dry density and moisture content of compacted soil fill materials shall be tested in accordance with this Section. The Contractor shall provide the Construction Manager with test results which demonstrate that acceptable compaction has been achieved as materials are placed.
10. Prior to commencing compaction, off-site fill and backfill soils shall be brought to within an acceptable range of their specified optimum moisture content per ASTM D-698 by either aerating the material if too wet or spraying with clean water if too dry.
11. Appropriate discing equipment shall be available at the site and shall be used to manipulate and dry soil or waste material that is too wet for proper compaction at no additional cost to the Owner.
12. Trenches shall be backfilled immediately following material installation. All trenches shall be kept dry and stable while open.
13. Soils installed above geosynthetic materials of the cover system shall be placed and compacted in such a manner and with appropriate equipment (e.g., low-ground-pressure earthwork equipment) so as not to damage the geosynthetic materials. The Contractor shall be responsible for maintaining the integrity of the geomembrane, geonet and geotextile materials during construction activities. Any geosynthetic material damaged by the construction activities shall be repaired by the Contractor at no additional cost to the Owner.
14. No vehicular traffic of any kind will be permitted on any exposed geosynthetic material.
15. When the Work is interrupted by rain, fill operations shall not be resumed until field tests indicate that the moisture content and density of the exposed fill are within the limits specified.
16. Thoroughly mix each lift before compaction to ensure uniform distribution of water content.

B. Subgrade Densification

1. Areas where fill (consisting of relocated on-site materials or off-site soil) is to be placed shall be cleared and grubbed in accordance with Section 02100. Following this activity, the subgrade within the limits of fill placement shall be proof-rolled on-grade using a heavy-duty, smooth-drum roller with a minimum weight of 10 tons. A minimum of four, complete coverages of the roller shall be completed over the entire area. Proof-rolling in this manner shall be completed over the entire cover system area to provide for a stable and uniform subgrade surface. Alternative equipment may be used if demonstrated to and approved by the Construction Manager.

In the event that a stable subgrade surface cannot be achieved within 12" of the final subgrade surface, the subgrade shall be undercut to a maximum depth of 24 inches, a woven geotextile placed, and the undercut area backfilled with suitable compacted soil. The excavated material gets spread and incorporated into other stable areas.

2. The finished surface of the interim cover that will support the cover system geomembrane shall also be proof-rolled similar to 1. above.
3. Proof-rolling shall continue until the proof-rolled surface is stable. Moisture conditioning of the subgrade, if required, shall be performed at no cost to the Owner.
4. All equipment used during subgrade densification shall be decontaminated prior to being demobilized from the site.

C. Surcharging

1. Surcharging fill (consisting of off-site materials) shall be placed over the PVD installation areas. Plan areas, heights, and staged-placement (if necessary) of surcharging fill shall be determined by the Construction Manager. After the Construction Manager determines that the consolidation settlements are achieved, the surcharging fill shall be either removed or graded and compacted as directed by the Construction Manager.

D. Protective Cover Soil (Vegetative Soil Cover)

1. Protective cover soil (vegetative soil cover) shall be placed in a single compacted lift thickness of 18 inches to maximize protection of the underlying geosynthetic materials.

2. Protective cover soil placement shall begin at the toe of the slope working upslope, perpendicular to the toe of slope.
3. A complete pass shall consist of the coverage of the entire lift to be compacted with the equipment specified.
4. Protective cover soil shall be compacted to 90 percent of the material's maximum dry density as determined by ASTM D 698 Standard Proctor.

E. Coarse Granular Materials

Coarse granular materials shall be compacted until no movement under equipment loading is observed. The visual inspection and approval of compaction will be conducted by the independent geotechnical testing firm.

F. Topsoil

1. Topsoil shall be lightly compacted in a uniform compacted lift thickness of 6 inches by the spreading low-ground-pressure equipment in a manner that does not over-consolidate the topsoil such that it is detrimental to the seeding operations.
2. Topsoil shall be tracked into place with track indentations perpendicular to slope.
3. The subgrade shall be scarified prior to topsoil placement to provide for interlocking between the topsoil and underlying cover layer material.

3.9 CHANNELS OR DITCHES

A. Stormwater Management Channels

1. Excavate channels and ditches to the width and depth dimensions indicated on the Drawings and to allow for the required thickness of channel lining material (e.g., rip-rap). Channel construction shall be staged as indicated on the Drawings.
2. Portions of the stormwater management channels and ditches shall have a vegetative lining that shall consist of the materials specified in Section 02270 - Soil Erosion and Sediment Control Measures.
3. Portions of the stormwater management channels and ditches may be stabilized with rip-rap, as per the Drawings and Specification Section 02207 - Aggregate Materials.

4. Positive drainage shall be provided throughout the entire length of all channels and ditches.
5. Care should be taken not to excavate channels and ditches below the grades indicated. Excessive channel or ditch excavation shall be backfilled to grade with satisfactory, thoroughly compacted material or with suitable stone or rip-rap.
6. All channels or ditches shall be maintained by the Contractor until final acceptance of the Work.

3.10 SITE GRADING

A. General

1. The Contractor shall perform all field survey work required under this Section. All field survey work shall be performed by a professional land surveyor registered in the State of Delaware subject to the requirements of Section 01050.
2. Grading operations shall not be started in an area until the appropriate erosion and sediment control measures have been installed and clearing and grubbing operations within the area have been completed.
3. Grade stakes shall be set at breaks in grade, along swales and as required for proper grading of the construction site. Before commencing construction operations, the Contractor shall survey and stake out contract limit lines as required to perform the work.
4. All stakes for surveying or other purposes shall be installed and maintained with all precautions to protect the existing landfill liner system and the final cover liner system. The Contractor shall submit the Stake Inventory Plan to the Construction Manager for approval prior to placement of any stake. The Stake Inventory Plan should include the effective numbering of all stakes and subsequent verification of all stakes removed as appropriate.
5. Perform grading operations so that disturbed areas are well-drained at all times. Maintain drainage ditches and keep them open and free from soil, debris, and leaves until final acceptance of the Work. Complete all grading on neat, regular lines conforming to the lines, grades, and contours shown on the Drawings. Perform grading work in proper sequence with all other associated operations.

6. The Contractor shall repair and re-establish grades in settled, eroded, rutted, or otherwise damaged areas. In damaged compacted areas, the surface shall be scarified, reshaped and compacted to the required density condition prior to further construction at no additional cost to the Owner.
7. Slopes shall be finished in conformance with the lines and grades as shown on the Drawings. When completed, the average plane of the slope shall conform to the slopes indicated on the Drawings. All slopes shall prevent the ponding of surface water.

B. Finish Grading

1. Finish grades of all surfaces shall be constructed to the lines and grades as shown on the Drawings and provide a smooth surface by rolling with a smooth-drum roller.
2. As-built surveys completed by the Contractor (at completion of prepared subgrade, protective cover soil, and topsoil) shall document the approved finished surfaces.

3.11 DRAINAGE AND DEWATERING

- A. To preclude surface water ponding in excavations, provide and maintain dewatering systems of sufficient capacity to remove water while each excavation is advanced or awaiting backfill.
- B. Do not allow sediment-laden water to flow into any watercourse or drainage way or over land without first filtering it through an Construction Manager-approved desilting device.
- C. Methods of dewatering excavations shall be at the Contractor's discretion. Continuous investigations and checks shall be made by the Contractor to ensure that the dewatering system employed is functioning properly.
- D. Any water that has come into contact with or is believed to have come into contact with waste materials shall not be allowed to move beyond the landfill's limit of waste. The Contractor shall manage such water and pump it to the Refinery wastewater treatment plant at no cost to the Owner. All pumping of water to the Refinery shall be coordinated with and approved by the Refinery (Premcor).

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

4.1 QUALITY ASSURANCE

- A. Perform work in accordance with the Construction Quality Assurance Plan.

4.2 SOIL MATERIALS SOURCE QUALITY CONTROL

- A. Perform source quality control in accordance with Section 02205. All quality control monitoring, investigation and testing shall be completed by the independent geotechnical testing firm approved by the Owner.

4.3 SOIL MATERIALS QUALITY CONTROL TESTING

- A. Perform quality control testing in accordance with Part 3.5 (Fill and Backfill) and Section 02205. All soil materials quality control monitoring, investigation and testing shall be completed by the independent geotechnical testing firm approved by the Owner.

4.4 SUBGRADE PREPARATION QUALITY CONTROL

- A. Proof-rolling of the entire area will be visually inspected by the Contractor's independent geotechnical testing firm and approved by the Construction Manager. Should any soft, loose or otherwise unstable zones be detected by the visual inspection, these areas shall be re-worked in accordance with Subsection 3.5B.

4.5 GRADING QUALITY CONTROL

- A. As-built surveys shall be completed by the Contractor as specified in Subsection 1.5E of this Section, and as otherwise necessary during the work to maintain required grades and to determine installed material quantities. The Construction Manager shall review and approve the surveys before the Contractor is permitted to proceed with additional placement of fill or other materials. The as-built surveys shall document that the approved finished surfaces are in accordance with the design.

END OF SECTION

SECTION 02205

SOIL MATERIALS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Subgrade Soil
- B. Interim Grading Soil Buffer
- C. Protective Cover Soil
- D. Topsoil

1.2 RELATED SECTIONS

- A. Section 01300 - Submittals
- B. Section 01400 - Quality Control and Quality Assurance
- C. Section 02100 - Site Preparation
- D. Section 02200 - Earthwork
- E. Section 02207 - Aggregate Materials
- F. Section 02270 - Soil Erosion and Sediment Control Measures

1.3 MEASUREMENT AND PAYMENT

- A. Measurement and payment for soil materials shall be in accordance with Section 02200, Part 1.3.

1.4 REFERENCES

- A. ASTM D422 - Particle-Size Analysis of Soils
- B. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soils Using Standard Effort
- C. ASTM D1556 - Density of Soil in Place by the Sand-Cone Method

- D. ASTM D2167 - Density and Unit Weight of Soil in Place by the Rubber Balloon Method
- E. ASTM D2216 - Laboratory Determination of Water (Moisture) Content of Soil, Rock and Soil-Aggregate Mixtures
- F. ASTM D2487 - Classification of Soils for Engineering Purposes
- G. ASTM D2922 - Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
- H. ASTM D2974 - Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
- I. ASTM D3017 - Water Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
- J. ASTM D4318 - Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- K. ASTM D4972 - pH of Soils

1.5 SUBMITTALS

- A. Geotechnical testing laboratory: Submit name, address and qualifications of key personnel of the laboratory(s) proposed by the Contractor to complete laboratory and field testing of soil materials within 2 weeks of Contract Award. Personnel shall be employed by an independent firm, as specified in Section 01400.
- B. Material Source: Submit name and address of proposed off-site soil materials source(s) within 2 weeks of Contract Award.
- C. Samples: Submit in air-tight containers 100-pound samples of each type of proposed off-site and off-property soil material to testing laboratory, as specified herein.
- D. Submit certification and laboratory testing results, indicating that each type of proposed soil material meets the requirements of this Section, at least 14 days prior to off-site material being delivered to the site. See Part 4 for testing requirements.

- E. Submit Certificates of Compliance for all proposed soil materials obtained from off-property locations. These certificates shall state that all proposed soil materials are environmentally-clean and satisfy all requirements of this Section.

PART 2 MATERIALS

2.1. SUBGRADE SOIL

- A. Subgrade soil shall be used to achieve preparatory grades for final cover system installation within the limits of the landfill. Subgrade soil shall be used only after excavation, filling and grading of on-site materials have been completed, unless otherwise approved by the Construction Manager.
- B. Subgrade soil shall be obtained from approved off-site locations and meet the following requirements:
1. Subgrade soil below the upper 6 inches (except for sediments removed from Guard Basins 5 and/or 6 and approved by DNREC for use as grading fill, if any):
 - Classify as GW, GM, GC, SW, SP, SM, SC, ML, ML-CL or CL per the Unified Soil Classification System (ASTM D2487).
 - Low to moderate plasticity for workability. The liquid limit shall be less than 40 and plasticity index less than 15 per ASTM D4318.
 - Shall not contain frozen material, vegetation, organic matter, stumps, roots or other deleterious wood matter, rubbish, gravel or rock fragments exceeding 1-inch in maximum dimension. Off-site subgrade soil shall be free of chemical contamination.
 2. Subgrade soil within the upper 6 inches:
 - Classify as SW, SP, SM, SC, or SC-SM per the Unified Soil Classification System (ASTM D2487).
 - Shall not contain frozen material, vegetation, organic matter, stumps, roots or other deleterious wood matter, rubbish, gravel or rock fragments exceeding 1-inch in maximum dimension. Off-site subgrade soil shall be free of chemical contamination.

2.2. DAILY COVER MATERIALS

- A. Daily cover materials shall be placed to cover landfill waste materials exposed in conjunction with site excavations, grading, and filling.
- B. Materials used for daily cover materials shall be obtained from on-site or off-site sources after the approval of the Construction Manager. Daily cover materials shall be free of rocks and fractured stones larger than 3-inch in maximum dimension, cobbles, debris, root, rootmass and other organic material, frozen material, and waste materials, and shall classify as SW, SM, SC, or SC-SM per ASTM D 2487.

2.3 INTERIM GRADING SOIL BUFFER

- A. Interim grading soil buffer shall consist of predominantly fine-grained, inorganic soil classifying as ML, ML-CL, CL or CH per ASTM D 2487 and possess a maximum particle dimension of 3 inches, except that occasional larger particles may be approved by the Construction Manager if rounded and oriented so as to not affect placement or compaction of the material.

2.4 PROTECTIVE COVER SOIL

- A. Protective cover soil shall be placed above the geosynthetic materials of the cover system to protect these materials and promote vegetal growth on the cover system.
- B. Material used for protective cover soil shall be obtained from off-site sources after the approval of the Construction Manager. Protective cover soil shall be free of rocks and fractured stones larger than 1-inch in maximum dimension, cobbles, debris, root, rootmass and other organic material, frozen material and waste materials, and shall classify as SW, SM, SC or SC-SM per ASTM D 2487.
- C. Protective cover soil shall consist of naturally-occurring, inorganic soils meeting the following gradation (dry weight basis):
 - 100 percent passing the 1-inch sieve
 - 70-100 percent passing the No.10 sieve
 - 12-35 percent passing the No.200 sieve
- D. Protective cover soil shall possess a pH of between 6 and 8.
- E. Unsuitable protective cover soil includes all materials not meeting the above requirements for protective cover soil. Materials considered to be too wet (5 percent or greater above optimum moisture content) shall be thin-spread and air-dried prior to placement.

2.5 TOPSOIL

Topsoil shall be obtained from off-site sources and placed atop installed protective cover soil within the entire limits of the final cover system and other newly-graded areas. Topsoil shall meet the following requirements:

- A. Shall consist of naturally-occurring organic soils suitable for growing vegetation. Organic content shall be at least 3 percent and not more than 10 percent.
- B. Shall be friable and classify as a loam or clay loam as defined by the USDA Soil Textural Classification System. Topsoil shall be free of debris, vegetation, stones and contamination.
- C. Shall possess low plasticity for workability. The liquid limit shall be less than 40 and plasticity index less than 15 per ASTM D4318.
- D. Shall possess a natural pH ranging from 6.0 to 7.5 and a low concentration of salts (conductivity less than 0.5 milliohms per cm).
- E. The Contractor shall have an agronomic study performed on the soils and follow augmentation application rates recommended by the soil testing laboratory.

PART 3. EXECUTION

Excavation, stockpiling, handling, processing, placement, grading and compaction of soil materials shall be in accordance with Section 02200.

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

4.1 QUALITY ASSURANCE

- A. Perform work in accordance with the Construction Quality Assurance Plan.

4.2 SOURCE QUALITY CONTROL

- A. Testing and Analysis of Subgrade Soil Material: Perform in accordance with ASTM D422, ASTM D698, ASTM D2216, and ASTM D4318.
- B. Testing and Analysis of Interim Grading Soil Buffer: Perform in accordance with ASTM D422, ASTM D698, ASTM D2216, ASTM D2487, and ASTM D4318.

- C. Testing and Analysis of Protective Cover Soil: Perform in accordance with ASTM D422, ASTM D698, ASTM D2216, ASTM D4318, ASTM D2487, and ASTM D4972.
- D. Testing and Analysis of Topsoil Material: Perform in accordance with ASTM D422, ASTM D2216, ASTM D2974, ASTM D4318, ASTM D4972, and agronomic study as required in Part 2.5.E.
- E. All samples analyzed shall be representative of the proposed materials. If tests indicate materials do not meet specified requirements, change material borrow source location and retest.
- F. Provide materials of each type from same source throughout the Work. Changes in borrow source will require retesting for approval.

4.3 QUALITY CONTROL TESTING

- A. The Contractor shall engage qualified personnel for testing of borrow sources and monitoring/testing compaction during fill placement, in accordance with Section 01400. The name, address and qualifications of any proposed independent laboratory shall be provided at the time of the Bid and are subject to approval by the Owner.
- B. At least three representative samples shall be collected from each proposed soil borrow source in the presence of the Construction Manager. At least one set of physical property tests, as required in Part 4.2 Source Quality Control, shall be completed on each sample and the results submitted to the Construction Manager prior to delivery of any off-site material and prior to placement of any on-site soil for use as subgrade soil, interim grading soil buffer, protective cover soil, or topsoil. In addition, at least one set of said tests shall be completed for each 5,000 cubic yards of each soil type or at any time that a significant change in physical properties of the respective soils is observed by the Construction Manager. The results of this frequency testing shall be reviewed and approved by the Construction Manager prior to use of that material for which the testing was completed.
- C. For topsoil, prior to initial material delivery, at least 6 representative samples shall be collected from each proposed topsoil borrow source in the presence of the Construction Manager. At least one set of the physical property and quality tests, as required in Part 4.2, and agronomic study as required in Part 2.4.E. shall be completed on each sample and the results submitted to the Construction Manager prior to delivery of any topsoil material. Once in place at the site, the Contractor shall also collect at least two samples per acre of installed topsoil and complete

one set of said tests for each sample to confirm acceptability and determine appropriate nutrient requirements.

- D. Standards for determining percent compaction and moisture content shall be determined by laboratory testing of the respective materials in accordance with ASTM D698.
- E. The dry density and moisture content of installed soil materials shall be tested in accordance with ASTM D1556, ASTM D2167, or ASTM D2922 in conjunction with ASTM D3017. A minimum of 1 test per 10,000 square feet of area (100-foot grid pattern) per lift of soil fill shall be performed. The Contractor shall provide the Construction Manager with test results and shall not proceed with additional fill lifts until approval, in writing, has been given by the Construction Manager. The Contractor shall schedule fill and compaction activities to avoid delays due to the processing of this submittal.

END OF SECTION

SECTION 02207

AGGREGATE MATERIALS

PART 1. GENERAL

1.1. SECTION INCLUDES

- A. Rip-Rap for Channel Lining and Pipe Outlets
- B. Coarse Granular Material for Cover System Perimeter Drain
- C. Sediment Traps

1.2. RELATED SECTIONS

- A. Section 01300 - Submittals
- B. Section 01400 - Quality Control and Quality Assurance
- C. Section 02200 - Earthwork
- D. Section 02205 - Soil Materials
- E. Section 02270 - Soil Erosion and Sediment Control Measures

1.3. UNIT PRICES - MEASUREMENT AND PAYMENT

- A. Rip-Rap for Channel Lining and Pipe Outlets: Incidental to lump sum payment for sediment and erosion controls in accordance with Section 02270 - Soil Erosion and Sediment Control Measures.
- B. Coarse Granular Material for Cover System Perimeter Drain: Lump Sum. Includes supplying off-site aggregate material, loading, hauling, stockpiling, backfilling, and compaction. Perimeter drain aggregate installed and accepted by the Construction Manager will be paid for on a lump sum basis in accordance with the Bid Schedule.
- C. Sediment Traps: Payment in accordance with Section 02270 - Soil Erosion and Sediment Control Measures.

1.4. REFERENCES

- A. AASHTO M147 - Materials for Aggregate and Soil-Aggregate
- B. ASTM C136 - Sieve Analysis of Fine and Coarse Aggregates
- C. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soils Using Standard Effort
- D. ASTM D2167 - Density and Unit Weight of Soil in Place by the Rubber Balloon Method
- E. ASTM D2487 - Classification of Soils for Engineering Purposes
- F. ASTM D2922 - Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
- G. ASTM D3017 - Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
- H. ASTM D4253 - Maximum Index Density (of Cohesionless, Free-Draining Soils), Using a Vibratory Table
- I. ASTM D4254 - Minimum Index Density (of Cohesionless, Free-Draining Soils), and Calculation of Relative Density
- J. ASTM D4318 - Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- K. Delaware Department of Transportation Standard Specifications, latest edition

1.5 SUBMITTALS

- A. Samples: Submit the appropriate size sample based on maximum particle size samples of each type of aggregate to testing laboratory, if results acceptable to Construction Manager are not available from borrow source for representative materials. Test results from the proposed borrow source shall not be dated more than 30 days prior to date of use.
- B. Materials Source: Submit name(s) of imported aggregate materials borrow source(s) within 2 weeks of Award of Contract.
- C. Submit Certificates of Compliance for all proposed aggregate materials. These certificates shall state that all proposed aggregate materials are environmentally-

clean and satisfy all material requirements of this Section. Submit certificates at least 14 days prior to material being delivered to the site.

- D. Submit certification and laboratory testing results, indicating that each type of proposed aggregate material meets the requirements of this Section, at least 14 days prior to material being delivered to the site. See Part 4 for testing requirements.

PART 2. MATERIALS

2.1. RIP-RAP FOR CHANNEL LINING AND PIPE OUTLETS

- A. Provide durable rock rip-rap for channel lining and pipe outlets with sizes in accordance with the Drawings.
- B. Rock shall be crushed and have a minimum specific gravity of 2.5.
- C. Aggregate shall meet the gradation and quality requirements of the Delaware Department of Transportation Specifications (latest edition).

2.2 COARSE GRANULAR MATERIAL FOR COVER SYSTEM PERIMETER DRAIN

- A. Provide coarse aggregate meeting the gradation requirements of AASHTO #3 and AASHTO #57.
- B. Rock shall be crushed and have a minimum specific gravity of 2.5.
- C. Aggregate shall meet the gradation and quality requirements of the Delaware Department of Transportation Standard Specifications (latest edition).

2.3 SEDIMENT TRAP AGGREGATES

- A. Provide coarse aggregates for sediment traps in accordance with sizes defined on the Drawings.
- B. Rock shall be crushed and have a minimum specific gravity of 2.5.
- C. Aggregate shall meet the gradation and quality requirements of the Delaware Department of Transportation Standard Specifications (latest edition).

PART 3. EXECUTION

3.1 STOCKPILING AGGREGATES

- A. Aggregates shall be stockpiled at locations designated by the Drawings or approved by the Construction Manager. Stockpile areas shall be cleared and leveled prior to stockpiling aggregates. All aggregates shall be stockpiled so as to prevent segregation and contamination. Aggregates obtained from different sources shall be stockpiled separately. Silt fence shall be installed along downgradient perimeter of aggregate stockpiles to minimize sediment migration from stockpiles.

3.2 STOCKPILE CLEANUP

- A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing water.

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

4.1 QUALITY ASSURANCE

- A. Perform work in accordance with the Construction Quality Assurance Plan.

4.2 SOURCE QUALITY CONTROL

- A. Testing and Analysis of Rip-Rap: Perform in accordance with gradation and quality requirements within the Delaware Department of Transportation Standard Specifications. Laboratory results available from commercial borrow sources, representative of proposed materials and satisfying said requirements, may be submitted prior to delivery. The Construction Manager shall determine acceptability of and, as appropriate, review and approve the results. Test results shall not be dated more than 30 days prior to date of use.
- B. Testing and Analysis of Cover System Perimeter Drain Aggregate: Perform in accordance with gradation and quality requirements within the Delaware Department of Transportation Standards and Specifications. Laboratory results available from commercial borrow sources, representative of proposed materials and satisfying said requirements, may be submitted prior to delivery. The Construction Manager shall determine acceptability of and, as appropriate, review and approve the results. Test results shall not be dated more than 30 days prior to date of use.

- C. All samples analyzed shall be representative of the borrow source. If tests indicate materials do not meet specified requirements, change material borrow source and retest at no cost to the Owner.
- D. Provide materials of each type from same source throughout the Work. Changes in borrow source will require retesting for approval.

4.3 QUALITY CONTROL TESTING

- A. At least one set of physical property tests, as required in Part 4.2, Source Quality Control, shall also be completed for each 1,000 tons of each type of delivered aggregate material or at any time that a significant change in physical properties of the proposed aggregate material is observed by the Construction Manager. The results of this frequency testing shall be reviewed and approved by the Construction Manager prior to use of that material for which the testing was completed.

END OF SECTION

SECTION 02270

SOIL EROSION AND SEDIMENT CONTROL MEASURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Silt Fencing
- B. Stormwater Channels
- C. Rock Filter Outlet
- D. Culvert Inlet Protection
- E. Rip Rap Outlet Protection
- F. Stone Check Dam
- G. Stabilized Construction Entrance
- H. Seeding

1.2 RELATED SECTIONS

- A. Section 01300 - Submittals
- B. Section 01400 - Quality Control and Quality Assurance
- C. Section 02000 - Site Work
- D. Section 02100 - Site Preparation
- E. Section 02200 - Earthwork
- F. Section 02205 - Soil Materials
- G. Section 02207 - Aggregate Materials
- H. Section 02292 - Geotextiles

1.3 LUMP SUM AND UNIT PRICES - MEASUREMENT AND PAYMENT

- A. Install Sediment and Erosion Controls: Lump sum. Includes supplying and installing all materials required for new sediment and erosion controls where indicated on the Drawings. Sediment and erosion controls installed and accepted by the Construction Manager will be paid for on a lump sum basis in accordance with the Bid Schedule.
- B. Supply and Place Vegetative Cover Soil: Payment in accordance with Section 02200, Part 1.3, Paragraph F & G.
- C. Supply and Place Topsoil: Payment in accordance with Section 02200, Part 1.3, Paragraph H & I.

1.4 REFERENCES

- A. Delaware Erosion and Sediment Control Handbook, Department of Natural Resources and Environmental Control, Division of Soil and Water Conservation.

1.5 SUBMITTALS

- A. Manufacturer's product data for all products shall be submitted for Construction Manager approval.
- B. Source, gradation, and quality information of all aggregate materials, as specified in Section 02207, for Construction Manager approval.

PART 2 PRODUCTS

2.1 SILT FENCING

- A. Standard Silt Fence
 - 1. Silt fence shall be Amoco 1380 Silt Stop or approved equal.
- B. Super Silt Fence
 - 1. Provide super silt fence materials in accordance with the Drawing C-34.

2.2 STORMWATER CHANNELS

- A. Provide riprap materials for 'trim-lined vegetated channel – trapezoidal' and 'riprap-lined channel – trapezoidal' in accordance with the standards and specifications presented on the Drawing C-35, Section 02207, and the Delaware Erosion and Sediment Control Handbook.
- B. Provide separation geotextiles in accordance with the Drawing C-35.

2.3 ROCK FILTER OUTLET

- A. Provide 'rock filter outlet' materials in accordance with the specifications presented on the Drawing C-34, Section 02207, and the Delaware Erosion and Sediment Control Handbook.
- B. Provide straw bales in accordance with the Drawing C-34 and standards and specifications presented in the Delaware Erosion and Sediment Control Handbook.
- C. Provide filtration geotextiles in accordance with the Drawing C-34 and Section 02292.

2.4 CULVERT INLET PROTECTION

- A. Provide 'culvert inlet protection' materials in accordance with the specifications presented on the Drawing C-35, Section 02207, and the Delaware Erosion and Sediment Control Handbook.
- B. Provide geotextiles in accordance with the Drawing C-35.

2.5 RIP-RAP OUTLET PROTECTION

- A. Provide 'rip-rap outlet protection' materials in accordance with the specifications presented on the Drawing C-35, Section 02207, and the Delaware Erosion and Sediment Control Handbook.
- B. Provide geotextiles in accordance with the Drawing C-35.

2.6 STONE CHECK DAM

- A. Provide 'stone check dam' materials in accordance with the specifications presented on the Drawing C-34, Section 02207, and the Delaware Erosion and Sediment Control Handbook.

- B. Provide geotextiles in accordance with the Drawing C-34.

2.7 STABILIZED CONSTRUCTION ENTRANCE

- A. Provide 'stabilized construction entrance' materials in accordance with the specifications presented on the Drawing C-34, Section 02207, and the Delaware Erosion and Sediment Control Handbook.
- B. Provide geotextiles in accordance with the Drawing C-34.

2.8 SEEDING

A. Seed

1. For temporary stabilization, see Table 02270-1. For permanent stabilization, see Table 02270-2.
2. Provide seeds in accordance with the Drawings C-33.

B. Fertilizer

1. Fertilizer shall be uniform in composition, free flowing, and delivered to the site fully labeled according to applicable state fertilizer laws and shall bear the name, trade name, trademark, and warranty of the product.
2. Based upon the results of the quality control testing required in Section 02205 for in-place topsoil, determine type and application rate of fertilizer from agronomic study (see Section 02205 Part 2.4) for approval by the Construction Manager. For bid purposes, Contractor shall assume application of 10-10-10 at the rate of 1,000 pounds per acre. Application of 40 lbs. per acre of nitrogen in the months of May, mid-July, and then at the end of August for areas seeded with Kentucky Bluegrass should also be assumed. Incorporate the fertilizer into the top 4 to 6 inches of topsoil.

C. Lime

1. Lime shall be applied to any areas where placed topsoil possesses a pH of 6 or less.
2. Lime shall be ground dolomite limestone containing at least 50 percent total oxides, calcium oxide plus magnesium oxide. Limestone shall be ground to fineness so that at least 40 percent shall pass through a 100-mesh sieve and 95 percent shall pass through an 8-mesh sieve.

3. Based upon the results of the quality control testing required in Section 02205 for in-place topsoil, determine application rate of lime from agronomic study (see Section 02205 Part 2.4) for approval by the Construction Manager. For bid purposes, Contractor shall assume lime to be applied at a rate of 120 pounds per 1,000 square feet, 2.5 tons per acre. Apply in all areas that shall receive permanent seeding. Apply with fertilizer.

D. Mulch

All mulching shall be done in accordance with the Mulching Material Selection Guide and Mulching Notes shown in Drawing C-33.

PART 3 EXECUTION

3.1 SILT FENCING

- A. Install standard silt fence and super silt fence as indicated on the Drawings.

3.2 STORMWATER CHANNELS

A. Vegetated Channel – Trapezoidal

1. Align, excavate, and shape channels in accordance with the lines and grades and details presented on the Drawings.
2. Seed channels as specified in this section.

B. Lined Channel – Trapezoidal

1. Install separation geotextile and rip-rap materials in locations and thicknesses as specified by the Drawings. Rip-rap shall meet the elevations, contours, and grades as specified by the Drawings. Geotextile shall be installed as shown on the Drawing C-35.
2. Rip rap material shall be as specified by the Drawings and in accordance with Section 02207.

3.3 ROCK FILTER OUTLET

- A. Install 'rock filter outlet' as specified by the Drawings C-31, C-32 and C-34.

3.4 CULVERT INLET PROTECTION

- A. Install 'culvert inlet protection' as specified by the Drawing C-35.

3.5 RIP-RAP OUTLET PROTECTION

- A. Install 'rip-rap outlet protection' as specified by the Drawings C-31, C-32 and C-34.

3.6 STONE CHECK DAM

- A. Install 'stone check dam' as specified by the Drawing C-31, C-32 and C-34.

3.7 STABILIZED CONSTRUCTION ENTRANCE

- A. Install 'stabilized construction entrance' as specified by the Drawing C-31, C-32 and C-34.

3.8 SEEDING

A. Site Preparation

1. Remove any objectionable material such as stones 2 inches or larger, clods, brush, roots, and trash from the delivered topsoil.
2. All vegetative soil cover shall be tracked into place (uncompacted) and scarified to a minimum depth of 4 inches with harrow, disc or other suitable equipment to provide for vegetation root penetration and interlocking with overlying topsoil to be placed. A minimum 6-inch thickness of topsoil shall then be placed above the vegetative soil cover in accordance with specification section 02200.

B. Soil Amendments

1. Apply lime and fertilizer at the necessary rates and thoroughly mix into the top 4 to 6 inches using a disc, springtooth harrow, or other suitable equipment. Harrowing and disking shall proceed with the general slope contour. Scarify the area and rake until the surface is leveled to provide a maximum of 2 inches in variation and soil is friable and of uniform fine texture.

C. Seeding

1. Apply seed mixture uniformly by hand, mechanical power-driven seeders, mechanical cyclone seeders, drop seeder, drill cultipacker, or hydroseeding equipment. The slurry for the hydroseeder shall contain seed and fertilizer only (no mulch).
2. Seeds not hydrocast shall be covered by at least $\frac{1}{4}$ to $\frac{1}{2}$ inch of soil accomplished by raking or dragging. After seeding and raking/dragging, the soil should be firmed with a corrugated roller to assure good seed-to-soil contact and improve plant emergence.

D. Mulching

1. Apply anchor mulch at the rates specified. Anchor erosion control blankets per manufacturer's recommendations. Moisten seedbed immediately after seed application, during periods of high temperature or low precipitation and when directed by Construction Manager.

E. Maintenance of Seeded Areas

1. In accordance with Specification Section 01740, the Contractor shall maintain all areas restored and revegetated during the work for twelve (12) months following Owner receipt of Contractor's Completion Certification. If during the maintenance period any work is found to be defective by the Construction Manager, the Contractor shall promptly, without cost to the Owner, repair or replace the work in accordance with the Specifications.
2. Water the seeded areas as necessary to maintain adequate moisture in the upper 4 inches of soil.
3. Inspect seeded areas for failures and necessary repairs due to poor vegetation growth, traffic, equipment damage, weather damage, or erosion. Provide replacements during the specified planting seasons for areas where repairs are deemed necessary by the Construction Manager. This shall include repairs and replacements due to erosional or weather-related damage.
4. If the Contractor applies permanent seeding within the specified Fall seeding period, then final inspection shall be held by November 7 or once revegetation coverage and survival has been determined to exceed 85 percent by a qualified soil scientist, ecologist or biologist engaged by the Construction Manager, whichever is earlier.

If the Contractor applies permanent seeding outside of the specified Fall seeding period, then final inspection shall be held whenever the revegetation coverage and survival has been determined to exceed 85 percent by a qualified soil scientist, ecologist or biologist engaged by the Construction Manager.

5. Owner acceptance of the construction work will occur following final inspection if the revegetation in all areas restored during the work meets and/or exceeds the standards for successful revegetation in accordance with the Delaware Department of Environmental Regulations and Control (DNREC) as follows:

- a. The standard for successful revegetation shall be the percent of groundcover of the vegetation which exists on the site. The Department will not approve less than a 70% groundcover of permanent plant species. No more than 1% of the total area may have less than 30% groundcover. A single or contiguous area exceeding 3,000 square feet may not have less than 30% groundcover.

- b. Trees, woody shrubs or deep-rooted plants may not be planted or allowed to grow on the revegetated area of cover system, unless otherwise allowed by the Department in the permit based on a demonstration that roots will not penetrate the cover system or drainage layer.

Successful revegetation shall be determined using the above standards by a qualified soil scientist, ecologist or biologist engaged by the Construction Manager.

6. If the revegetation does not meet the standard and is found to be defective by the Construction Manager during the final inspection, the Contractor shall overseed, fertilize, lime and mulch as determined by the Construction Manager and in accordance with the Specifications.

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

4.1 QUALITY ASSURANCE

- A. Perform work in accordance with the Construction Quality Assurance Plan.

4.2 CONTRACTOR QA/QC REQUIREMENTS

- A. The submittals defined in Part 1.5 are to be submitted to the Construction Manager for review prior to material delivery or construction of control devices.
- B. Contractor shall keep a daily log for inspection of all sediment and erosion control devices. The status of such devices shall be noted and details of necessary repairs or upkeep shall be recorded. The Construction Manager will review the Sediment and Erosion Control Log periodically for conformance.
- C. Contractor is responsible for implementing recommendations of the Certified Construction Reviewer (CCR) stated in weekly inspection reports.

Table 02270-1

Temporary Seeding by Rates, Depths, and Dates

Species	Seeding Rate ⁶		Optimum Seeding Dates ¹ O=Optimum Planting Period; A=Acceptable Planting Period							Planting Depth ³
Certified Seed	lb/Ac ⁵	lb/1000 sq. ft.	Coastal Plain			Piedmont			All	
			2/1-4/30	² 5/1-8/14	8/15-10/31	3/1-4/30	² 5/1-7/31	8/1-10/31	10/31-2/1	
Annual Ryegrass	125	4	O	A	O	O	A	O	All	0.5 inches 1-2” sandy soils

Notes:

1. Winter seeding requires 3 tons per acre of straw mulch for proper stabilization.
2. May be planted throughout summer if soil moisture is adequate for seeding area can be irrigated.
3. Applicable on slopes 3:1 or less.
4. Fifty pounds per acre of Annual Lespedeza may be added to ½ the seeding rate of the above species.
5. Use varieties currently recommended for Delaware. Contact a County Extension Office for information.
6. Warm season grasses such as Millet or Weeping Lovegrass may be used between 5/1 and 9/1 if desired. Seed at 3-5 lbs. per acre. Good on low fertility and acid areas. Seed after frost through summer at a depth of 0.5".

Table 02270-2

Permanent Seeding and Seeding Dates

Seeding Mixtures	Seeding Rate ¹		Optimum Seeding Dates ²						
			O=Optimum Planting Period; A=Acceptable Planting Period						
	lb/Ac	lb/1000 sq. ft.	Coastal Plain			Piedmont			All ⁴
Certified Seed ³			2/1-4/30	5/1-8/14	8/15-10/31	3/1-4/30	5/1-7/31	8/1-10/31	10/31-2/1
Strong Creeping Red Fescue	100	2.3							
Kentucky Bluegrass	70	1.61							
Redtop	5	0.11	O	A	O	O	A	O	Add
Plus White Clover ⁵	3	0.07							100
									lbs./ac.
									Winter
									Rye

Notes:

1. When hydroseeding is the chosen method of application, the total rate of seed should be increased by 25%.
2. Winter seeding requires 3 tons per acre of straw mulch. Planting dates listed above area average for Delaware. These dates may require adjustment to reflect local conditions.
3. All seed shall meet the minimum purity and minimum germination percentages recommended by the Delaware Department of Agriculture. The maximum % of weed seeds shall be in accordance with Section 1, Chapter 24, Title 3 of the Delaware Code.
4. Cool season species may be planted throughout summer if soil moisture is adequate or seeded area can be irrigated.
5. All leguminous seed must be inoculated.

END OF SECTION

SECTION 02280
PREFABRICATED VERTICAL DRAINS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Manufacturing, furnishing and installing prefabricated vertical drains (PVD) and discharge collection system to dewater the filter cake solids within the soft areas of the Industrial Waste Landfill (IWL), as indicated on the Drawings.
- B. The PVD shall consist of a band-shaped plastic core enclosed in a geotextile fabric-wrapped jacket and shall be spaced and arranged as indicated on the Drawings.

1.2 RELATED SECTIONS

- A. Section 01300 – Submittals
- B. Section 01400 – Quality Control and Quality Assurance
- C. Section 02000 – Site Work
- D. Section 02100 – Site Preparation
- E. Section 02200 – Earthwork

1.3 MEASUREMENT AND PAYMENT

A. Measurement

- 1. PVD - The length of accepted drains will be the distance the installation mandrel tip penetrates below the specified surface plus the required cutoff length above the designated working surface.
- 2. Obstruction Clearance – The length of accepted obstruction clearance will be the length from the designated working space at the time of installation to the depth penetrated by the auger or spud, or if directed, to the bottom of the obstruction. Obstruction clearance shall be measured for payment only when authorized by the Construction Manager.

B. Payment

- 1. The accepted quantities will be paid for at the Contract unit price for the following items:

- | Pay Item | Unit of Measurement |
|---|---------------------|
| a) Furnish and install PVD..... | Foot |
| b) Obstruction Clearance..... | Foot |
| 2. a) Item a) includes trial installations and splices. | |
| b) Item b) includes pre-augering, spudding or performing other acceptable methods to clear obstructions so that PVD may be satisfactorily installed, including disposing of any surplus pre-augered or obstruction clearance materials. | |
| 3. Payment will consist of all materials, equipment, labor and incidentals necessary to complete the work. | |
| 4. No payment will be made for the following: | |
| a) Unacceptable trial drain installations | |
| b) Drains that are not installed and anchored to the required depth | |
| c) Clearing obstructions caused by the Contractor | |
| d) PVD placed in excess of the designated depth unless additional lengths are directed by the Construction Manager | |
| e) PVD installed more than 6 inches from the staked location, damaged or improperly installed | |
| f) Repair of damaged liner system due to PVD installed at improper location or depth | |

1.4 REFERENCES

- A. ASTM D 638 – Tensile Properties of Plastics.
- B. ASTM D 1621 – Compressive Properties of Rigid Cellular Plastics.
- C. ASTM D 3776 – Mass Per Unit Area (Weight) of Fabric.
- D. ASTM D 3786 – Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method.
- E. ASTM D 4354 – Sampling of Geosynthetics for Testing.
- F. ASTM D 4491 – Water Permeability of Geotextiles by Permittivity.

- G. ASTM D 4533 – Trapezoid Tearing Strength of Geotextiles.
- H. ASTM D 4595 – Tensile Properties of Geotextiles by the Wide-Width Strip Method.
- I. ASTM D 4632 – Grab Breaking Load and Elongation of Geotextiles.
- J. ASTM D 4716 – Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
- K. ASTM D 4751 – Determining Apparent Opening Size of a Geotextile.
- L. ASTM D 4833 – Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
- M. ASTM D 4884 – Strength of Sewn or Thermally Bonded Seams of Geotextiles.
- N. ASTM D 5199 – Measuring the Normal Thickness of Geosynthetics.
- O. ASTM D 5261 – Measuring Mass per Unit Area of Geotextiles.
- P. ASTM D 6917 – Selection of Test Methods for Prefabricated Vertical Drains (PVD).

1.5 SUBMITTALS

- A. The Contractor shall submit written notice to the Construction Manager at least 21 days prior to the installation of any PVD. The Contractor shall submit to the Construction Manager at least 14 calendar days prior to installation:
 - 1. Manufacturer's Certification that delivered materials meet specification requirements, prior to delivery of PVD. Provide supplier's Certification that delivered material has been properly stored away from sunlight, moisture and dirt until shipping.
 - 2. Shipping tickets including lot number or control number.
 - 3. Samples of the unspliced drains to be used, and 3 samples of any proposed splices. The sample of unspliced drain shall be at least 10 feet long. Samples of spliced PVD shall be long enough to include the splice plus 2 feet of unspliced drain on both sides of the splice.
 - 4. Manufacturer's literature documenting the physical and mechanical properties of the drain (as a minimum those properties required by the specifications) and other similar projects where the same drain has been installed including details

of performance on these projects.

5. Details of the sequence and method of installation. The submittal shall, at minimum, contain the following specific information concerning the scheduled work:
 - a) Size, type, weight, maximum pushing force, actual pushing force for anticipated set-up, rated energy of vibrating hammer, track bearing pressure, and configuration of the installation rig
 - b) Shop drawings showing PVD layout, locations, depths, and identification numbers
 - c) Dimensions, weight, material and length of the mandrel consistent with Part 1.8 of this Section.
 - d) Details of PVD anchorages that are anticipated
 - e) Proposed apparatus for 'safety stop' to prevent the mandrel from advancing beyond the preset depth and damaging the existing geomembrane liner
 - f) Means of determining the depth of the advancing drain at any given time and the length of the drain installed at each location
 - g) Proposed apparatus for 'manually-pushing PVD' within extremely soft areas where no low-ground-pressure equipment can access (see Drawings and Part 3.1 B.)
 - h) Detailed description of proposed installation procedures
 - i) Estimated minimum, maximum, and average rates of PVD installation
 - j) Estimated schedule of PVD installation
 - k) Proposed method(s) for splicing PVD
 - l) Proposed method(s) for penetrating subsurface obstructions
 - m) Proposed plan for constructing a level working-surface for installation of PVD
 - n) Manufacturer's literature on PVD material and installation
 6. Acceptance by the Construction Manager does not relieve the Contractor of its responsibilities to provide materials and equipment necessary to install PVD in accordance with the Drawings and Specifications.
- B. The Contractor shall submit an affidavit from the Manufacturer certifying that the materials or products delivered to the job meet the requirements specified in Part 2. However, such certification shall not relieve the Contractor from the responsibility of complying with any added requirements specified herein. Two sets of certified laboratory tests for the tests required in Part 2 from an independent geosynthetics

testing laboratory shall be submitted prior to delivery of any PVD and at least 7 days prior to PVD installation. These tests shall be performed on samples representative of PVD material to be used for this project.

- C. The PVD Installer (PVDI) shall submit summaries of three or more projects of similar size and complexity on which it has successfully installed PVD within the last five years. Present the following information for each project listed as a reference:
 - 1. Project name, location and completion date
 - 2. Surface and subsurface conditions
 - 3. The PVD installation equipment and technique
 - 4. The minimum, maximum and average rates of PVD installation
 - 5. The cost and duration of PVD installation
 - 6. Average length of PVD installed and total linear footage of PVD installed
 - 7. Provide current phone numbers and business addresses for the owner/designer, geotechnical consultant

1.6 QUALIFICATIONS

- A. The PVD Manufacturer shall be a specialist in the manufacturing of PVD and shall have produced a minimum of 5 million linear feet of PVD that have been used in successful installations.
- B. The PVDI shall have a minimum of 5 years experience with the installation of at least 5 million linear feet of PVD and shall have successfully completed three or more PVD installations of similar size and complexity within the last 5 years. The PVDI shall be an approved installer of the PVD Manufacturer. Provide at least one superintendent and one operator for the PVD equipment with a minimum of 5 years experience with PVD installation and the equipment, respectively. The Contractor shall provide detailed information on the training and experience of any operators with less than 5 years of experience for approval by the Construction Manager. In no case shall any superintendent or operator have less than 2 years experience with the installation of PVD.
- C. The Contractor shall submit the qualifications and experience of the proposed PVDI to the Construction Manager for review and approval at least three (3) weeks prior to the commencement of PVD installation activities.

1.7 DELIVERY, STORAGE AND HANDLING OF MATERIALS

- A. PVD materials shall be labeled or tagged in such a manner that the information for sample identification and other quality control purposes can be read from the label. As a minimum, each roll shall be identified on the jacket and core by the Manufacturer as to lot or control numbers, individual roll number, date of manufacture, manufacturer and product identification.
- B. During shipment and storage, the PVD shall be wrapped in heavy paper, burlap, plastic or similar heavy-duty protective covering. The PVD shall be protected from sunlight, mud, dirt, dust, debris, and other detrimental substances during shipping and on-site storage.
- C. All material that is damaged during shipping, unloading, storage, or handling and does not meet the minimum requirements of the Specifications will be rejected by the Construction Manager and shall be removed from the site by the Contractor immediately. No payment shall be made for rejected material.

1.8 PROTECTION OF EXISTING GEOMEMBRANE LINER

- A. IWL is underlain by an existing double liner system consisting of a primary 60-mil geomembrane liner overlying a secondary 60-mil geomembrane liner. Typical liner system details are presented in Figures 2.1 and 2.2. Waste thickness at PVD installation areas is reported to range from 26 to 35 feet. PVD length will be 15 feet, therefore shall terminate minimum 11 feet above the existing liner to avoid the potential for damaging the integrity of the existing liner. PVDI shall provide a 'safety stop' apparatus approved by the Construction Manager to prevent the mandrel from advancing beyond the preset depth and damaging the existing liner. The 'safety stop' apparatus may include, but not limited to, any or a combination of the following:
 - 1. Preset length of mandrel,
 - 2. Mechanical 'safety stop' apparatus, or
 - 3. Warning signal at pre-determined depth.

PART 2 MATERIALS

2.1 PVD

- A. The PVD shall be constructed of newly manufactured materials from an approved manufacturer and consist of a polypropylene drainage core enclosed in or integrated with a geotextile jacket. The geotextile jacket shall allow free passage of pore water to the core without loss of soil material or piping. The core shall provide continuous vertical drainage channels.

- B. The PVD shall be capable of resisting all bending, punching, compression and tensile forces imposed during installation and during the design life of the drain without damage and so that the discharge capacity is not adversely affected.
- C. The PVD shall be resistant against wet rot, mildew, bacterial action, insects, salts, acids, alkalis, solvents, and any other significant ingredients in the site groundwater for a period of 3 years.
- D. The PVD shall have a minimum equivalent diameter of 50 mm (2 inches) using the following definition of equivalent diameter:

$$d_w = \frac{(a + b)}{2}$$

d_w = diameter of a circular drain equivalent to the band-shaped drain

a = width of the band-shaped drain

b = thickness of the band-shaped drain

- E. The PVD shall be band-shaped with an aspect ratio (width divided by thickness) not exceeding 40.
- F. One single type of PVD shall be used on the project unless otherwise specified or approved by the Construction Manager. The PVD shall have the following minimum properties.

Table 02280-1

PVD

<u>Property</u>	<u>Test Method</u>	<u>Required Minimum Value</u>
1. Width		4 inches
2. Thickness	ASTM D 5199	0.171 inches
3. Discharge Capacity	ASTM D 4716	
	@ 1.45 psi	2 gal per min.
	@ 43.5 psi	1.65 gal per min.

- G. The PVD geotextile jacket and core components shall also meet the minimum properties shown on Table 02280-2 and 02280-3, respectively.

- H. Anchor plates, if used, shall not exceed 8 inches in the maximum horizontal dimension.

2.2 GEOTEXTILE JACKET

- A. The jacket shall be a nonwoven, heat-set, continuous filament polypropylene geotextile capable of resisting all bending, punching, and tensile forces imposed during installation and during the design life of the drain.
- B. The geotextile jacket material shall not be subject to localized damage (e.g., punching through the filter by sand/gravel particles).
- C. The geotextile jacket material shall be rigid enough to withstand lateral earth pressures due to embedment and surcharge so that the vertical flow capacity through the core will not be adversely affected.
- D. The geotextile jacket material shall be flexible enough to bend smoothly during installation and induced consolidation settlement without damage.
- E. The geotextile jacket material shall not undergo cracking and peeling during installation.
- F. Test the geotextile jacket material in both saturated and dry conditions. The geotextile jacket material shall conform to the following minimum requirements:

Table 02280-2
GEOTEXTILE JACKET

<u>Property</u>	<u>Test Method</u>	<u>Required Minimum Value</u>
Mass	ASTM D 5261	2.5 oz/yd ²
Grab Tensile Strength	ASTM D 4632	64.3 lbs.
Grab Tensile Strength	ASTM D 638	82.8 lbs.
Grab Elongation	ASTM D 1621	50%
Trapezoidal Tear	ASTM D 4533	10 lbs.
Permittivity	ASTM D 4491	0.47 sec ⁻¹
AOS	ASTM D 4751	0.067 mm

2.3 CORE

The core shall be continuous polypropylene plastic material with grooved channels, a pattern of protruding studs, or mesh-type materials fabricated to promote drainage along the axis of the PVD. The core shall have the following minimum properties:

Table 02280-3

CORE

<u>Property</u>	<u>Test Method</u>	<u>Required Minimum Value</u>
Thickness	ASTM D 5199	0.135 inches
Mass	ASTM D 3776	0.74 oz/ft
Grab Tensile Strength	ASTM D 638	224 lbs.

2.4 LATERAL DRAINAGE LAYER (LDL)

The synthetic landfill gas collection media ('double-sided' geocomposite consisting of drainage net and geotextile on both sides), overlying the waste materials and PVD's upper ends within IWL, shall also serve as the LDL for PVD. The LDL will intercept and convey water that discharges from PVD to multiple collection points for subsequent removal.

2.5 DISCHARGE COLLECTION SYSTEM

The vertical access pipes shall be installed to collect discharged water from PVD, unless otherwise approved by the Construction Manager. A discharge collection system shall consist of a 24-inch diameter corrugated vertical polyethylene pipe with perforations at bottom 3 feet and surrounded by aggregates.

PART 3 EXECUTION

3.1 PVD

A. Installation Equipment

1. PVD shall be installed with approved modern equipment of a type that will cause a minimum of disturbance of the waste materials during the installation operation and maintain the mandrel in a vertical position.

2. PVD shall be installed using a mandrel or sleeve that shall be inserted (i.e., pushed or vibrated) into the sediments. The mandrel or sleeve shall protect the drain material from tears, cuts, and abrasions during installation, and shall be retracted after each drain is installed.
3. The mandrel shall be advanced with constant load or constant rate of advancement. A vibrator with an eccentric moment of at least 500 in-lbs. shall be available for use in areas where constant load or constant rate of advancement methods cannot install the PVD to the design depths.
4. The mandrel or sleeve shall be sufficiently stiff to prevent wobble or deflection during installation.
5. The mandrel or sleeve shall be provided with an anchor plate or similar arrangement at the bottom to prevent the soil from entering the bottom of the mandrel during the installation of the drain and to anchor the drain tip at the required depth at the time of mandrel withdrawal. The dimensions of the anchor shall conform as closely as possible to the dimensions of the mandrel so as to minimize disturbance of waste materials. The Construction Manager shall determine the acceptability of the anchorage system and installation procedure. The choice of anchoring system is the responsibility of the PVDI, but it shall be the smallest surface area required to secure the PVD.
6. If the fly ash sediments are too soft and the anchor tends to be pulled out at the time of mandrel withdrawal, the PVDI shall submit an alternative anchoring system to the Construction Manager for approval.

B. Trial PVD Installation

1. Prior to the full-scale installation of production PVD within IWL, the Contractor shall demonstrate that its equipment, method, and materials produce a satisfactory installation in accordance with the Drawings and Specifications. Trial PVD provided to the satisfaction of the Construction Manager will be measured and paid for specified for production PVD in Section 1.3.
2. Number of trial PVD and their location(s) shall be designated by the Construction Manager.
3. Additional trial PVD may be required by the Construction Manager, for each 200,000 linear feet of PVD installed, or when significant changes in subsurface conditions or installation are noted.
4. Approval by the Construction Manager of the method or equipment used to

install trial PVD shall not constitute, necessarily, acceptance of the method for the remainder of the project. If, at any time, the Construction Manager considers that the method of installation does not produce satisfactory PVD, the PVDI shall alter his method and/or equipment as necessary to comply with these specifications.

C. Installation Procedure

1. Unless otherwise approved by the Construction Manager, the Contractor shall remove the Temporary Surface Cover from the soft areas of IWL, which was installed to act as a bird deterrent measure and also limit the potential for continued leachate generation.
2. Contractor shall provide a level work area (minimum of one-percent, maximum three-percent cross slope) of adequate width for efficient operation of PVD installation equipment.
3. PVD shall be located, numbered, and staked out using a baseline and benchmark provided by the Construction Manager. Stake-out shall use pin flags, plastic pipe (or other measures) that will minimize the potential for damage to the liner system. The PVDI shall protect the stake-out and be responsible for any additional stake-out. The installed location of each PVD shall not vary by more than 6 inches from the plan locations designated on the Drawings.
4. PVD that are more than 6 inches from design plan location or are damaged or improperly installed will be rejected and abandoned in place. The PVDI shall install additional PVD to replace the damaged ones.
5. PVD shall be installed from the designated working surface to the elevation shown on the Drawings, or to such elevation as directed by the Construction Manager. The Construction Manager may vary the depths, spacings, or the number of drains to be installed, and may revise the plan limits for this work as necessary to ensure the design and functional intent of the PVD is best achieved.
6. PVD shall be installed in the presence of the Construction Manager's representative at all times.
7. During PVD installation, the PVDI shall provide the Construction Manager with suitable means of determining the depth of the advancing drain at any given time and the length of the drain installed at each location.
8. PVD shall be installed using static methods. Vibratory or static-vibratory methods shall be available for use only in areas where the static methods

cannot install the PVD to the design elevations. PVD that cannot be installed to the design penetration using only static methods shall be advanced with the use of a vibratory hammer to be considered for compensation.

9. Equipment for installing PVD shall be plumbed prior to installing each drain and shall not deviate from the vertical more than 5 inches in 10 feet during installation of any drain.
10. The QC Manager shall supply to the Construction Manager, by the morning following each work day, a summary of PVD installed that day. The summary shall include drain type, locations, and length to nearest one foot, quantity of PVD installed at that location, the locations of any PVD that do not extend to the plan elevation, and the locations and depths where vibration was used to install the PVD.
11. A PVD shall be abandoned before reaching the design penetration when the rate of installation is less than 6 inches per second with the full static force and maximum vibrator output. The use of falling-weight impact hammer is not allowed.
12. Installation techniques requiring driving or jetting will not be permitted. The injection of limited amounts of water shall be allowed to facilitate anchoring of any PVD after being approved by the Construction Manager.
13. The installation shall be performed without any damage to the drain during advancement or retraction of the mandrel. In no case will alternate raising or lowering of the mandrel during advancement be permitted. Raising of the mandrel will only be permitted after completion of PVD installation.
14. Where obstructions are found below the working surface, that cannot be penetrated using normal and accepted procedures, the Contractor shall complete PVD from the elevation of the obstruction to the working surface and notify the Construction Manager's representative.
15. The PVD material shall be cut neatly at its upper end at the prepared subgrade and, therefore, there shall be no PVD protruding above the subgrade at each PVD location.
16. The PVDI shall observe precautions necessary for protection of any existing utilities, structures and field instrumentation devices. The Contractor shall pay for the replacement of any instrumentation equipment that has been damaged or becomes unreliable as a result of his operations, in accordance with the Drawings and Specifications.

17. If, at any time, the method of PVD installation is considered not to produce satisfactory PVD by the Construction Manager, the PVDI shall alter its method and/or equipment as necessary to comply with the Drawings and Specifications.

D. Obstruction Clearance Procedures

1. Satisfactory installation may require clearing man-made or natural obstructions that prevent the proper insertion of the mandrel or sleeve and installation of PVD.
2. The Contractor may use augering, spudding or other approved methods to loosen the soil and remove any obstruction material before installing PVD. The obstruction clearance procedure is subject to approval of the Construction Manager. However, such approval shall not relieve the Contractor of his responsibility to clear obstructions in accordance with the Drawings and Specifications.
3. Where obstructions are encountered:
 - a) Immediately notify the Construction Manager before completing PVD and before installing other PVD.
 - b) Attempt to install PVD adjacent to the obstructed location.
 - c) Based on the results of this attempt and when directed, attempt to install a second offset PVD within 18 inches horizontally of the obstructed drain, or if directed, implement obstruction clearance procedures and install PVD at the specified location.
4. If augering, use augers with a minimum outside diameter equal to the largest horizontal dimension of the mandrel, sleeve, shoe or anchor, whichever is greatest. The maximum outside diameter of the auger shall not be more than 3 inches greater than the minimum outside diameter.

E. Splicing

1. Splicing of PVD material shall be done by stapling in a workman-like manner and so as to insure structural and hydraulic continuity of the drain. At the splice, upper portion of the jacket shall be external to the lower portion.
2. A maximum of one splice per drain installed will be permitted without specific permission from the Construction Manager.
3. The jacket and core shall be overlapped a minimum of 6 inches at any splice.

3.2 LATERAL DRAINAGE LAYER (LDL)

- A. As specified in Part 2.4, the synthetic landfill gas collection media ('double-sided' geocomposite consisting of drainage net and geotextile on both sides) overlying the waste materials and PVDs' upper ends shall also serve as the LDL for the PVD system.

3.3 DISCHARGE COLLECTION SYSTEM

- A. Contractor shall install a collection system to collect liquids discharged from the PVDs. The collection system shall generally consist of a shallow trench drain comprised of perforated piping (minimum 6 inch diameter) surrounded by pea gravel or similar granular material (max. dimension of 1 inch) installed along the downslope edge of the LDL to intercept and convey PVD liquids to a collection point (sump). Liquids will be removed from the collection point and transported by the Contractor to the existing leachate collection manhole or pre-treatment plant, as directed by the Construction Manager, for subsequent management and treatment as landfill leachate.

PART 4 INSTRUMENTATION

4.1 GENERAL

- A. The Contractor shall install instruments to enable monitoring of vertical movements and carry out monitoring of the movements during the duration of the works.
- B. The depths and locations of all instruments shall be determined by the Construction Manager.
- C. The Contractor shall follow the instructions of the Manufacturer in the installation, calibration and testing of all measuring instruments and equipment. The Contractor shall inform the Construction Manager at least 2 days prior to installation of the equipment.

4.2 PERMANENT SETTLEMENT REFERENCE STATIONS

- A. The Contractor shall be responsible for establishing permanent settlement reference stations in locations approved by the Construction Manager. The permanent settlement reference stations shall be located on stable ground.

4.3 METHOD OF MONITORING

A. Settlement of Waste Materials

Settlement of waste materials due to surcharging (fill) is to be measured by means of settlement plates. The Contractor shall submit its proposed settlement plate for approval. Settlement plates are positioned before the surcharging (fill) is laid.

B. Location and Protection of Settlement Plates

The settlement plates shall be placed at locations indicated on the pre-approved Drawing. They shall be located in areas that are least affected by construction vehicles. They shall be properly protected with a wooden barricade, 3-foot high and labeled with visible reference numbers. Heavy compaction equipment shall not approach within 5-foot of projecting instruments. Damaged instruments shall be repaired or replaced by the Contractor at no additional cost to the Owner within seven days.

C. Frequency of Measurement

The frequency or the interval of measurement shall be submitted by the Contractor and approved by the Construction Manager.

D. Supply, Installation and Monitoring of Settlement Stations

Installation of precise instrument involves the supply and installation of the instruments at positions as indicated by the Construction Manager.

1. Temporary benchmarks

The temporary benchmarks will be installed at the nearby stable structure or remote from the surcharging (fill) area and marked on an end bearing pile or similar structure.

2. Settlement plates

The precise settlement measurements shall be referenced to the temporary benchmarks. The measuring instruments shall be a precise level, capable of allowing readings to be read to 0.1 inch.

E. Plotting

The result should be plotted during the period of measurement.

4.4 INSTALLATION OF INSTRUMENTS

- A. The method of installation shall be the most advantageous method recommended by the manufacturer and shall be subject to the approval of the Construction Manager.

- B. The Contractor shall install settlement gauges and reference settlement stations before commencement of earthworks.

4.5 PROTECTION OF INSTRUMENTS

- A. All instruments shall be protected against damage during the duration of the works and the period of maintenance. Instruments damaged during the above shall be immediately replaced by the Contractor at no additional cost to the Owner.

4.6 INSTRUMENTS NOT FUNCTIONING

- A. All instruments shall be designed to ensure proper functioning over the required period of monitoring. Instruments not functioning during the period of monitoring shall be immediately replaced by the Contractor at no additional cost to the Owner. The Construction Manager's decision as whether an instrument is functioning or not shall be final.

PART 5 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

5.1 QUALITY ASSURANCE

Perform work in accordance with the Construction Quality Assurance Plan.

5.2 QUALIFICATIONS

The minimum qualifications of the Manufacturer and PVD Installer, as defined in Part 1.6, are to be submitted to the Construction Manager for review and approval in accordance with Part 1.5.

5.3 MANUFACTURERS SAMPLING AND TESTING

- A. Testing for assembled PVD, geotextile jacket, and core shall be performed by a Geosynthetic Accreditation Institute (GAI) accredited geosynthetic testing laboratory approved by the Construction Manager.
- B. Individual components of PVD (geotextile jacket and core) as well as the assembled PVD shall be randomly sampled and tested by the Manufacturer, prior to shipment, to satisfy ASTM D 4354, but no less than at least once every 200,000 linear feet of PVD, to evaluate the required properties summarized in Tables 02280-1, 02280-2 and 02280-3. Certified test results on each sample shall be submitted to the Construction Manager. Samples not meeting the minimum requirements specified shall result in the rejection of the applicable rolls.

5.4 INDEPENDENT CONFORMANCE TESTING

- A. Upon, or prior to, delivery of the rolls of PVD, the QA Consultant shall verify that samples are removed and forwarded to the Independent Laboratory for testing to verify conformance with the test methods and results listed in Tables 02280-1, 02280-2 and 02280-3.
- B. Using the packing list provided by the Manufacturer, rolls shall be selected for sampling at a minimum frequency of one sample per 200,000 linear feet of PVD designated for the project. Each different manufacturing run or lot shall be represented by at least one sample.

5.5 TEST RESULTS

- A. If the average test values for the sample meet all of the values given in Tables 02280-1, 02280-2 and 02280-3 and the Manufacturer's guaranteed minimum values, the sample passes.
- B. If the average test values for the sample do not meet one or more of the required values, additional evaluation procedures will be implemented.
 - 1. For the failing parameter(s), test two additional samples (a sample is defined by the number of specimens required for the specified test method). Another GAI-Accredited Laboratory at the discretion of the QA Consultant and the Construction Manager may perform these tests.
 - 2. If the average test values for each of the two additional samples meet the required values, the roll and adjacent rolls pass and are acceptable.
 - 3. If one or more of the average test values do not meet the requirements, reject the roll, collect samples from the closest numerical roll on both sides of the failed roll and test for the failed parameter(s). If testing continues to not meet the requirements, the Construction Manager shall determine further testing protocol for identifying the limits of rejected rolls or may reject the entire lot of material.

5.6 CONTRACTOR QA/QC REQUIREMENTS

A. Daily Quality Control Log

The Contractor's inspector shall maintain a daily quality control log during all phases of PVD installation. This log shall document the daily progression of the material installation from delivery to final acceptance. The daily log shall designate those construction activities that influence the integrity of the material during installation. The log, at a minimum, shall include entries and detailed documentation of the following:

1. Weather (temperature, winds, precipitation)
2. Preparation activities.
3. Roll number of PVD at each completed and accepted installation location.
4. Labels or tags of PVD including the manufacturer's name, lot or control number, individual roll number, and date of manufacture.
5. Repairs and replacements.
6. Document obstruction clearance and splicing activities.
7. Equipment used to install PVD.
8. Location plan and tabulated depths of installed PVD.

B. Inspection of PVD Installation

The Contractor shall carry out visual inspections of PVD during installation. Any faulty areas relating to PVD integrity and/or continuity shall be repaired by the Contractor using pre-approved techniques, at no additional cost to the Owner. Such repairs shall be reported to the Construction Manager by means of a daily quality control (QC) log.

C. Installation Records

Submit proposed installation record forms that include date and time of installation, rig number, PVD identification number, top elevation, installed length, length of pre-augering or spudding, description of obstructions or other interruptions, daily quantity summary, total quantity summary, and other contract summary items. Interim reports shall be submitted weekly. A complete copy shall be submitted within two weeks after completion of PVD installation.

END OF SECTION

SECTION 02290

GEOMEMBRANE FOR FINAL COVER SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Manufacturing, furnishing and installing 60-mil smooth and textured geomembrane for the final cover system of the Industrial Waste Landfill (IWL).
- B. Textured geomembrane shall be installed to cover the east slope of the IWL. Smooth geomembrane shall be installed to cover the remainder of the IWL.

1.2 RELATED SECTIONS

The general provisions of the Contract, including the General Requirements of the Specifications, apply to the work specified in this Section. Related sections include:

- A. Section 01300 - Submittals
- B. Section 01400 - Quality Control and Quality Assurance
- C. Section 02200 - Earthwork
- D. Section 02291 - Gas Collection/Drainage Geocomposite
- E. Section 02292 - Geotextiles
- F. Section 02295 - Direct Shear Interface Testing

1.3 MEASUREMENT AND PAYMENT

Furnish and install smooth and textured High Density Polyethylene (HDPE) geomembrane. Unit Price. Includes supplying, unloading, storing, deploying, seaming, and anchoring of the HDPE geomembrane atop the bedding geotextile of the final cover system. Also includes all field and Independent Laboratory testing and other quality control procedures. Allowance will be made for geomembrane in anchor and drainage trenches; however, no allowance will be made for waste or seam overlaps. Actual installed quantity will be based on horizontal plan dimension shown on record survey. Geomembrane installed and accepted by the Construction Manager will be paid for on a unit price basis in accordance with the Bid Schedule.

1.4 REFERENCES

The publications listed below form a part of the specification to the extent referenced. The publications are referenced in the text by basic designation only. The latest editions of the following test standards and codes shall apply to the Work.

- A. ASTM D 638 - Tensile Properties of Plastic
- B. ASTM D 746 - Brittleness Temperature of Plastics and Elastomers by Impact
- C. ASTM D 792 - Specific Gravity (Relative Density) and Density of Plastics by Displacement
- D. ASTM D 1004 - Initial Tear Resistance of Plastic Film and Sheeting
- E. ASTM D 1203 - Volatile Loss from Plastics Using Activated Carbon Methods
- F. ASTM D 1204 - Linear Dimensional Changes of Non rigid Thermoplastic Sheeting or Film at Elevated Temperature
- G. ASTM D 1238 - Flow Rates of Thermoplastics by Extrusion Plastometer
- H. ASTM D 1505 - Density of Plastics by the Density-Gradient Technique
- I. ASTM D 1603 - Carbon Black in Olefin Plastics
- J. ASTM D 1693 - Environmental Stress-Cracking of Ethylene Plastics
- K. ASTM D 3895 – Determining Oxidative Induction Time (OIT) for Polyolefins
- L. ASTM D 4354 - Sampling of Geosynthetics for Testing
- M. ASTM D 4833 - Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
- N. ASTM D 5199 - Measuring Normal Thickness of Geotextiles and Geomembranes
- O. ASTM D 5321 - Determining the Coefficient of Soil-and-Geosynthetic or Geosynthetic- and-Geosynthetic Friction by Direct Shear Method
- P. ASTM D 5397 - Evaluation of Stress Crack Resistance of Polyolefin Geomembranes using Notched Constant Tensile Load Test

- Q. ASTM D 5596 - Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
- R. ASTM D 5721 – Air-Oven Aging of Polyolefin Geomembranes
- S. ASTM D 5820 - Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
- T. ASTM D 5994 – Measuring Core Thickness of Textured Geomembrane
- U. ASTM D 6392 - Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
- V. ASTM D 6693 - Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
- W. Federal Test Method Standards 101 C 2065.1 - Puncture Resistance and Elongation Test
- X. GRI Test Method GM9 – Cold Weather Seaming of Geomembranes
- Y. ASTM D 7238 – Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
- Z. GRI Test Method GM13 – Test Properties, Testing Frequency and Recommended Warrant for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
- AA. GRI Test Method GM19 – Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.5 SUBMITTALS

- A. Submit the following for approval at least 30 days prior to delivery of the first shipment:
 - 1. Certified test reports within the requirements of standards of testing methods specified herein shall be submitted to the Construction Manager. The material Manufacturer and Contractor must satisfy the Construction Manager that the material they offer to furnish and install shall meet in every aspect the requirements set forth in these specifications and the requirements of Table 02290-1. The Contractor shall transmit to the Construction Manager all information given to them by the Manufacturer

or Supplier prior to approval for furnishing and installing any such material.

2. Manufacturer's quality assurance (QA)/quality control (QC) manual.
 3. Manufacturer's recommended delivery, storage, handling, and installation procedures including placement and seaming.
 4. Properly identified 12-inch by 12-inch samples of a smooth and a textured geomembrane.
 5. Full and complete installation of shop drawings at a minimum:
 - a. Panel layout plan of geomembrane.
 - b. Details of seaming panels.
 - c. Details of anchorage and penetration.
 6. Description of tools and equipments to be used during installation.
 7. Certification that the welding rods to be used for extrusion welding have the same properties of the geomembrane to be used for this project.
 8. Testing laboratory proposed by the Manufacturer for testing of resin and sheet materials.
 9. Qualifications of the geomembrane Manufacturer, Installer, Master Seamer and personnel performing field seaming operations for this project, QC Inspector, and Independent Laboratory. See Part 1.6 for requirements.
 10. Certification by geomembrane Manufacturer that the Installer is approved to install geomembrane materials.
- B. Submit the following for approval at least 7 days prior to delivery of shipment:
1. Certification of Resin Quality
 2. Certified test results for all raw material and sheet materials with quality control certificates (See Part 2.5.C).
- C. Submit the following during construction on a daily basis:

1. Certified field seam test results
2. Certified Independent Laboratory test results
3. Seam repair log
4. Daily QC log (See Part 4.4A)
5. Certificate of Acceptance of Geomembrane Subsurface by Installer.

D. Submit the following at the completion of construction:

1. Record drawings of geomembrane installation showing field panel and corresponding roll numbers, seam numbers, and locations of patches, destructive seam samples, and penetrations. (See Part 4.5).
2. The Manufacturer shall provide a 20-year warranty to the Owner against manufacturing defects. The warranty shall include defective product found to be not in compliance with requirements of this specification. The warranty shall include replacement of defective geomembrane with new material. The warranty shall not include defects or failures due to improper installation, design, or selection of cover materials.
3. The Contractor shall provide a 2-year warranty to the Owner against improper installation or workmanship. The warranty shall include problems associated with improperly compacted or prepared subgrade, damage due to construction vehicles on the geomembrane, puncture of the geomembrane caused by improper materials in the subgrade or the cover, or any other instances which are determined to be the result of improper installation procedures and not in accordance with Part 3.3. The warranty shall include complete excavation and removal of the cover material and existing geomembrane and replacement with new materials to restore the site to its original condition.

1.6 QUALIFICATIONS

A. Manufacturer

The Manufacturer shall have produced the proposed geomembrane sheets for at least 5 completed projects having a total minimum area of 10 million square feet.

B. Installer

The Installer is responsible for field handling, deploying, seaming, anchoring, and field QC testing of the geomembrane. The Installer shall have installed the

proposed geomembrane material for at least 5 completed projects having a total minimum area of 2 million square feet.

C. Master Seamer

The Installer shall provide a minimum of one Master Seamer for work on this project. The Master Seamer shall have completed a minimum of 1,000,000 square feet of the proposed geomembrane using the same type of seaming equipment and geomembrane thickness specified for this project.

D. Superintendent

The Superintendent is the person hired by the Installer, who is responsible for supervising the Installer's activities related to the geomembrane installation. The Superintendent shall have provided a supervision during installation of the proposed geomembrane material for at least 5 completed projects having a total minimum area of 2 million square feet.

E. QC Inspector

The QC Inspector is the person or corporation hired by the Contractor, who is responsible for monitoring and documenting activities related to the QC of the geomembrane from manufacturing through installation. The QC Inspector shall have provided QC inspection during installation of the proposed geomembrane material for at least 5 completed projects having a total minimum area of 2 million square feet.

F. Independent Laboratory

The Independent Laboratory shall have provided QC and/or Quality Assurance (QA) testing of the proposed geomembrane and geomembrane seams for at least five completed projects having a total minimum area of 2 million square feet. The Independent Laboratory shall be accredited via the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP) for the tests the Independent Laboratory will be required to perform.

1.7 DIRECT SHEAR INTERFACE TESTING

Direct shear interface testing shall be performed in accordance with Section 02295.

1.8 DELIVERY, STORAGE AND HANDLING

- A. The geomembrane shall be handled and stored in accordance with the Manufacturer's recommendations. The Manufacturer's recommendations should be on site and shall be also provided to the Delaware Department of Natural Resources & Environmental Control (DNREC) prior to receipt of materials on site.
- B. The geomembrane shall be packaged, shipped, stored and handled by appropriate means so that no damage is incurred. Materials shall be delivered only after the required submittals have been received and approved by the Construction Manager. The Contractor shall provide the necessary equipment and crew to unload delivered materials in the presence of the Quality Assurance (QA) Consultant. The geomembrane shall be adequately protected at all times from puncture, abrasion, excessive heat, degradation of the material, adhesion of individual whorls of a roll or layers or other damaging circumstances. Appropriate handling equipment and techniques, as recommended by the Manufacturer and approved by the Construction Manager, shall be used. Any geomembrane damaged as a result of poor delivery, storage, or handling methods shall be repaired or replaced, as determined by the QA Consultant, at no additional cost to the Owner.
- C. Any equipment used shall not damage the geomembrane by handling, trafficking, or other means. No vehicular traffic of any kind will be allowed directly on the geomembrane. All personnel working on the geomembrane shall not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane. The method used to unroll the rolls shall not cause scratches or crimps in the geomembrane and shall not detrimentally rut the supporting soil, as determined by the QA Consultant. The method used to place the rolls shall minimize wrinkles (especially differential wrinkles between adjacent panels/rolls). Adequate temporary anchorage (e.g., sand bags) shall be placed to prevent uplift by wind without damaging the geomembrane.
- D. The Installer shall not allow handle cardboard or core tubes containing staples to contact or be stored on or near the geomembrane.

PART 2 PRODUCTS

2.1 RAW MATERIALS

Resin used in manufacturing geomembrane sheets shall be made of virgin uncontaminated ingredients. No more than 2 percent regrind, reworked, or trim material in the form of chips or edge strips shall be used to manufacture the geomembrane sheets. All regrind, reworked, or trim materials shall be from the same manufacturer and exactly the same formulation as the geomembrane sheet being produced. No post consumer materials or water-soluble ingredients shall be used to produce the geomembrane.

2.2 SHEET MATERIALS

A sheet is defined as a manufactured seamless smooth and textured geomembrane unit with a width equal to or greater than 5 feet. Geomembrane sheets shall be non-reinforced and uniform in color, thickness, and surface texture (for textured geomembrane). The sheets shall be free of and resistant to fungal or bacterial attack and they shall be free of cuts, abrasions, holes, blisters, contaminants and other imperfections.

2.3 GEOMEMBRANE PHYSICAL PROPERTIES

Sheets shall conform to the minimum physical requirements listed in Table 02290-1 and GRI GM-13. Manufacturer's property specifications shall be submitted a minimum of 30 days prior to delivery of geomembrane to the site.

2.4 GEOMEMBRANE TESTING

A. Manufacturing Sampling And Testing

1. Geomembrane testing shall be performed by the Independent Laboratory approved by the Construction Manager.
2. Each resin batch shall be tested and the results submitted to the Construction Manager to ensure the consistency of the raw material quality. Any resin batch that fails to meet the specified physical properties shall not be accepted for manufacturing the geomembrane. Manufactured geomembrane sheets shall be randomly sampled and tested by the Manufacturer, prior to shipment, to satisfy ASTM D 4354 but no less than at least once every 100,000 square feet to evaluate the required properties summarized in Table 02290-1. Certified test results on each sample shall be submitted to the Construction Manager. In addition, one 12-inch by 12-inch minimum size sample, along with appropriate identification, shall be provided to the Construction Manager for possible quality assurance testing and permanent record of actual furnished material. Samples not meeting the minimum requirements specified shall result in the rejection of the applicable rolls. Extrudate rod shall be of the

identical resin type as that used in the geomembrane sheet. Each batch of extrudate shall be tested for specific gravity, melt index and carbon black content. Any extrudate batch that fails to meet the physical properties required for the resin shall be rejected.

B. Independent Conformance Testing of Geomembrane

1. Upon, or prior to, delivery of the rolls of geomembrane, the QA Consultant shall verify that samples are removed and forwarded to the Independent Laboratory for testing to verify conformance with the test methods and results listed in Table 02290-1.
2. Using the packing list provided by the Manufacturer rolls shall be selected for sampling at a minimum frequency of one sample per 100,000 square feet of each type of geomembrane designated for the project. Each different manufacturing run or lot shall be represented by at least one sample.

C. Test Results

1. If the average test values for the sample meet all of the values given in Table 02290-1 and the Manufacturers guaranteed minimum values, the sample passes.
2. If the average test values for the sample do not meet one or more of the required values, additional evaluation procedures will be implemented.
 - a. For the failing parameter(s), test two additional samples (a sample is defined by the number of specimens required for the specified test method). Another GAI Accredited Laboratory at the discretion of the QA Consultant and the Construction Manager may perform these tests.
 - b. If the average test values for each of the two additional samples meet the required values, the roll and adjacent rolls are acceptable.
 - c. If one or more of the average test values do not meet the requirements, reject the roll, collect samples from the closest numerical roll on both sides of the failed roll and test for the failed parameter(s). If testing continues to not meet the requirements the Construction Manager shall determine further testing protocol for identifying the limits of rejected rolls or may reject the entire lot of material.

PART 3 EXECUTION

3.1 PREPARATION OF SUBGRADE FOR GEOMEMBRANE

A. Prior to installation of the bedding geotextile and geomembrane, all vegetation, rocks larger than 1-inch in diameter, debris, sharp objects, etc., shall be removed from the surfaces to be covered with the geomembrane. Any depressions, ruts, etc., in the surfaces to be covered shall be filled with soil and compacted to final grade. The finished surface shall be smooth with no abrupt projections to damage the geomembrane. The subgrade surface shall then be proof-rolled (densified) in accordance with Section 02200 3.5.B. The subgrade surface shall be observed daily by the Contractor and the Construction Manager to evaluate the surface condition. Any damage to the subgrade caused by the Contractor's operations shall be repaired at no additional cost to the Owner. No geosynthetic material shall be placed on a subgrade that has become too soft or too wet, as determined by the Construction Manager, until it has been properly reconditioned and/or recompacted. Immediately prior to bedding geotextile (and overlying geomembrane) placement, the Contractor shall certify in writing by completing the Certificate of Acceptance of Geomembrane Subsurface that the surface on which the geosynthetic materials are to be placed is acceptable.

3.2 ANCHOR TRENCH

The perimeter anchor trench shall be excavated to the lines, grades, and width shown on the Drawings. The QC Inspector shall verify that the anchor trench has been constructed in accordance with the Drawings. Slightly rounded corners shall be provided in the trench where the geomembrane adjoins the trench so as to avoid sharp bends in the geomembrane. No loose soil, rocks or debris shall be allowed to underlie the geomembrane in the anchor trench. Leading edges of the trench shall be smooth and even. All anchor trenches shall be kept dry at all times and allow for drainage of precipitation to prevent ponded water in trenches. After placement of the geosynthetics, the trench shall be backfilled with suitable materials using 4 to 6-inch loose lifts in accordance with Specification 02200, and compacted using equipment that will not damage the geosynthetics.

3.3 INSTALLATION

A. General

1. The Contractor shall furnish the services of a full-time competent English speaking field technical installation supervisor to supervise installation of the geomembrane. The geomembrane shall be placed atop a bedding geotextile, over the prepared and approved surface to be lined, in such a manner as to require minimum handling. Any portion of geomembrane damaged during installation shall be removed or repaired, at the

Construction Manager's discretion and as specified in Part 3.7, at no additional cost to the Owner.

2. The geomembrane shall be laid out and installed in accordance with the applicable panel installation drawings approved by the Construction Manager. The geomembrane shall be installed by the Installer approved by the Construction Manager.
3. All geomembrane shall be installed in a downslope manner to minimize the potential of surface water flowing beneath previously placed geomembrane.
4. The Contractor shall at all times maintain a clean work area to protect the geomembrane from incidental damage. This activity shall be done on an ongoing basis throughout the Work.

B. Field Panel Placement

1. Only those geomembrane panels that can be temporarily anchored and seamed together on the same day shall be deployed. No more than one (1) acre of geomembrane (including any overlying single-sided or double-sided drainage geocomposite) shall be exposed at any time, unless otherwise approved by the Construction Manager. Cover soil placement shall proceed in a manner to satisfy this requirement.
2. In general, seams shall be oriented parallel to the line of maximum slope. In corners and odd-shaped geometric locations, the number of seams shall be minimized. No horizontal seam shall be less than 5 feet from the top or bottom of slopes exceeding 10 percent or from areas of potential stress concentrations. No cross-slope seams shall be permitted on slopes exceeding 10 percent.
3. A seam numbering system compatible with a panel numbering system shall be employed during the Work.
4. Adjacent geomembrane panels shall be overlapped a nominal 4 inches prior to dual hot-wedge seaming, unless the Construction Manager approves a lesser overlap due to limitations of the Contractor's welding equipment. In no case shall an overlap of less than 3 inches be approved. Areas cut to remove wrinkles or 'fishmouths' shall be cut along the ridge of the wrinkle and seamed. The required minimum geomembrane overlap for extrusion welding shall also be 4 inches.

5. HDPE sheet of appropriate thickness shall be used for all penetrations where indicated on the Drawings.

3.4 FIELD SEAMING

A. General

1. All sheets shall be overlapped a minimum of 4 inches. In corners and odd-shaped geometric locations, the number of field seams shall be minimized. Seaming shall extend to the outside edge of sheets to be placed in anchor and/or drainage trenches. Seaming shall not be conducted in the presence of standing water and/or soft subgrades. The seam area shall be cleaned of all dust, dirt, and foreign material prior to and during seaming.
2. The geomembrane shall have field seams that equal or exceed the strength requirements presented on Table 02292-2.

B. Trial Seams

1. Trial seams shall be made on test strips of geomembrane to verify that seaming conditions are adequate. All trial seams shall be made at a location selected by the QA Consultant in the area to be seamed and in contact with the underlying bedding geotextile. Such test seams shall be made at the start of each day prior to production seaming, whenever there is a change in seaming personnel or seaming equipment, and at least once every five hours and at the end of each day, by each seamer and seaming equipment used that day. One sample shall be obtained from each trial seam. This sample shall be at least 2 feet long by 1-foot wide with the seam centered lengthwise. Four random specimens, each measuring 1-inch wide, shall be cut from the sample by the Contractor using the appropriate ASTM cutting tool. Two specimens shall be field-tested by the Contractor for bonded seam strength and two specimens shall be field-tested for peel adhesion using an approved quantitative tensiometer. Tensiometer jaw separation speed shall be 2 inches per minute. If the field tests fail to meet the minimum specified seam requirements presented on Table 02290-2, the entire operation shall be repeated. If the additional trial seam fails, the seaming apparatus or seamer shall not be accepted or used for seaming until the deficiencies are corrected and two consecutive successful trial seams are achieved.
2. All welded seams installed by the seaming apparatus/operator between the period of time when an acceptable coupon specimen and a deficient coupon specimen were obtained shall be evaluated. The evaluation shall consist of cutting three 12-inch wide by 12-inch long samples from the

suspect deficient seam. The samples shall be taken at locations directed by the Construction Manager. The samples shall be field-tested by the CONTRACTOR in shear and peel. If any of the three samples fails to meet the shear and peel strength requirements presented on Table 02290-2, the entire length of deficient welding shall be repaired. Required repair shall consist of placing a patch cap over the deficient seam(s). The cap material and installation shall be in accordance with this Specification. The cap shall extend a minimum of 12 inches from the center line of the deficient weld in all directions.

3. All trial weld samples shall be marked with the date, roll/seam number, operator, ambient temperature, and welding machine number and temperature. A copy of this information shall be attached to each coupon specimen.

C. Seam Preparation

1. Prior to seaming, the seam area shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material. No seaming of the HDPE geomembrane shall be conducted when the material is exposed to moisture from either dew or precipitation. Seams shall be aligned to create the fewest possible number of wrinkles and fishmouths. All seam interfaces shall be visually examined for scratches, blemishes, flaws, and texture.
2. Trimming of seams and patches shall be accomplished using a shielded blade or hook-knife. Whenever possible, the cutting of the geomembrane shall be from the underside, in an upward motion. Any trimming of test strips or patch pieces on the geomembrane shall be performed with a scrub sheet between the geomembrane and the cutting operation. All trimming of seams shall be completed at least 50 feet ahead of seaming operations.
3. For extrusion-welded seams, a small hand-held electric rotary grinder with circular disc grit grinding paper shall be used to remove oxidation at the seam locations. The grinding plate shall be approximately 4 inches in diameter, and No. 80 grit paper shall be used. The depth of the grinding shall be less than 10 percent of the sheet thickness, but generally be only 5 percent of the sheet thickness. Grinding shall not extend beyond extrudate bead. Grinding shall precede welding by approximately 15 minutes and shall be oriented perpendicular to the seam direction rather than parallel to it.

D. Seaming

1. General

- a. The approved seaming techniques for the Work are dual hot-wedge and extrusion fillet welding. The dual hot-wedge technique shall be used for panel seams in open areas that can effectively accommodate the seaming equipment. The extrusion welding techniques shall be used on panel seams in limited work space areas, for welding of geomembrane to pipe penetrations and appurtenances (e.g. gas vents), and for patching coupons removed for destructive testing purposes and/or repair of poor welds, tears, or punctures in the geomembrane.
- b. Welding of HDPE shall not take place in temperatures less than 40 degrees F unless it can be proven via test strips that acceptable seams can be fabricated at lower temperatures. In cases where welding is to be performed in temperatures less than 35 degrees F, GRI GM-9 shall be implemented. Ambient temperatures for seaming shall not exceed 105 degrees F, measured one foot above the geomembrane.
- c. Where weather conditions are marginal for seaming, as determined by the Construction Manager, trial seams, as described in Part 3.4B, shall be made, and conditioned as necessary, to decide if production seaming can proceed.
- d. All dual hot-wedge welding equipment shall be capable of continuously monitoring and controlling the temperature of the contact zone where the equipment is actually fusing the geomembrane material. This will ensure that changes in ambient conditions will not significantly affect the integrity of the weld.
- e. All seams shall be tightly bonded upon completion of welding activities. No 'fishmouths' shall be allowed within the seam area. Where 'fishmouths' occur, the material shall be cut, overlapped and extrusion-welded.

2. Dual Hot-Wedge Seaming

- a. The operator shall keep constant visual contact with the temperature controls, as well as with the completed seam coming out of the machine. Occasional adjustments of the temperature or speed may be necessary to maintain a consistent weld of high integrity. When the speed or temperature is adjusted a trial weld shall be performed to reflect such changes.

- b. If an extensive amount of 'squeeze out' is observed, reduce the temperature and/or pressure to correct the situation.
- c. Cleaning of the dual hot-wedge welder shall be performed as needed to maintain quality performance of equipment.
- d. A smooth-insulating plate or heat-insulating fabric shall be placed beneath the hot-welding apparatus after usage.

3. Extrusion Fillet Seaming

- a. Grinding of geomembrane sheets shall be completed in accordance with Part 3.4.C. A hot-air or hot-wedge welder may be used to tack weld sheets together in order to hold them in proper position for extrusion welding.
- b. The extrusion welder is to be purged of all heat-degraded extrudate in the barrel prior to beginning of a seam. This shall be done every time the extruder is restarted after a 2-minute or longer downtime. The purged extrudate shall be properly disposed of.
- c. Extrudate in the form of a molten, viscous bead shall be deposited over the overlapped seam. The center of the extrudate shall be directly over the edge of the upper sheet. The extrudate shall cover the grind marks on each side of the upper sheet.
- d. The minimum extrudate thickness shall be approximately two times the specified sheet thickness measured from the top of the bottom sheet to the top or crown of the extrudate. Excessive squeeze-out (or flashing) is acceptable as long as it is equal on both sides and does not interfere with subsequent vacuum box testing.
- e. After seaming, visual inspection of the extrudate bead shall be made, particularly for straight-line alignment, height, and uniformity of surface texture. There shall be no bubbles or pockmarks in the extrudate. A 'cap strip' shall be placed over the entire seam where excessive grinding is observed.
- f. Seam weld runs shall terminate at a panel end or tail off gradually. Where extrusion fillet welds are temporarily terminated long enough to cool, they shall be ground prior to applying new

extrudate over the existing seams. This restart procedure shall be followed on patches, pipes, fittings, and appurtures.

- g. "T" and "Y" seams shall be patched in accordance with Part 3.7.D.
- h. Power supply equipment shall be in good working order and be able to continuously supply power. A generator shall be placed on a scrub sheet of geomembrane. Oil and gas used to power the generators shall not be stored within the areas to receive geomembrane. Electric cord junction boxes shall be padded on the underside to protect the geomembrane from damage during installation. The Contractor is advised that excess lengths of electrical cords will reduce the available voltage to the welding equipment, which may affect the welding process.

3.5 FIELD SAMPLING AND TESTING

A. Non-Destructive Field Seam Testing

The Contractor shall non-destructively test the continuity of all field seams over their full length using the appropriate equipment and procedures as outlined in Part 3.8. Any deviation from these procedures shall be subject to approval by the Construction Manager prior to use. Testing shall be performed as the seaming work progresses, not at the completion of field seaming. All geomembrane field seams shall be air pressure tested unless otherwise approved by the Construction Manager. Any seams which fail shall be documented and repaired in accordance with Part 3.7.C.

B. Destructive Field Seam Testing

1. Location and Frequency

The Contractor shall obtain a minimum of one destructive test sample per 500 feet of field seam length, or portion thereof, at locations specified by the QA Consultant. Sample locations shall not be identified prior to seaming.

2. Size and Disposition of Samples

The samples shall be a minimum of 12 inches wide by 40 inches long with the seam centered lengthwise. Each sample shall be cut into three equal pieces with one piece retained by the Contractor, one piece to be shipped to the Independent Laboratory, and the remaining piece given to the Construction Manager for quality assurance testing and permanent record. Each sample shall be tagged to identify: roll/panel number; seam number; top sheet; date and time cut; ambient temperature; seaming unit

designation; name of seamer; and welding apparatus temperature and pressures (where applicable).

3. Field Testing

The Contractor shall cut ten, 1-inch wide replicate specimens from its sample using the appropriate ASTM cutting tool. Five specimens shall be tested for shear strength and five for peel adhesion using an approved field quantitative tensiometer. To be acceptable, four out of five replicate test specimens must meet the specified seam strength requirements presented on Table 02290-2. If the field tests pass, the Independent Laboratory testing shall be conducted in accordance with Part 3.6. If the field tests fail, the seam shall be repaired in accordance with Part 3.7. Certified test results on all seams shall be submitted prior to acceptance of the seam.

3.6 INDEPENDENT LABORATORY TESTING

Five specimens shall be tested for shear strength and five for peel adhesion in accordance with ASTM D 6392. To be acceptable, four out of five replicate test specimens must meet the specified requirements presented on Table 02290-2. If the Independent Laboratory tests fail, the seam shall be repaired in accordance with Part 3.7.C. Certified test results on all seams shall be submitted prior to acceptance of the seam.

3.7 DEFECTS AND REPAIRS

A. Identification

Immediately prior to covering the geomembrane, all seams and non-seam areas shall be visually inspected by the CONTRACTOR and Construction Manager for defects, holes, or damage due to weather conditions or construction activities. At the discretion of the Construction Manager, the surface of the geomembrane shall be brushed, blown, or washed by the Contractor if the amount of dust, mud, or foreign material inhibits inspection of the geomembrane or the functioning of the overlying material.

B. Evaluation

Each suspicious location shall be non-destructively tested. Each location that fails non-destructive testing shall be repaired and re-tested by the CONTRACTOR until it passes.

C. Repair Procedures

Defective seam areas may be overlaid with a strip of new material and seamed (cap-stripped). Alternatively, the seaming path shall be retraced to an intermediate location a minimum of 10 feet on each side of the failed seam location. At each location a 12-inch by 12-inch minimum size seam sample shall be taken for 2 additional shear strength and 2 additional peel adhesion tests using an approved quantitative field tensiometer. If these tests meet the specified seam strength requirements presented on Table 02290-2, then the remaining seam sample portion shall be sent to the Independent Laboratory for 5 shear strength and 5 peel adhesion tests in accordance with ASTM D 6392. If these laboratory tests meet the specified seam strength requirements presented on Table 02290-2, then the seam shall be cap-stripped between that location and the original failed location. If field or laboratory tests fail, then the process is repeated. After cap-stripping, the entire cap-stripped seam shall be non-destructively tested. Certified test results on all repaired seams shall be submitted for approval by the Construction Manager prior to covering the seamed areas.

D. Patches

Tears, holes, blisters, "T" and "Y" seams and areas with un-dispersed raw materials or foreign material contamination shall be repaired with patches. Patches shall have rounded corners, be made of the same geomembrane, and extend a minimum of 6 inches beyond the edge of defects. Minor localized flaws shall be repaired by spot welding or seaming as determined by the QA Consultant. Repairs shall be non-destructively tested. The QA Consultant may also elect to perform a destructive seam test on a suspicious area.

3.8 NON-DESTRUCTIVE SEAM TESTING PROCEDURES

A. The Contractor shall nondestructively test all field seams where accessible over their full length using a vacuum test unit, air pressure testing, or other approved method. Continuity testing shall be carried out as the seaming work progresses in accordance with the following procedures unless otherwise recommended by the geomembrane Manufacturer and approved by the Construction Manager.

B. Vacuum Testing (for extrusion fillet seams only)

1. Test shall be performed with a tank pressure of approximately 5 psi (10 inches of Hg.) gauge.
2. Examine the geomembrane seam through the viewing window for not less than 10 seconds.
3. The next adjoining area shall overlap the previously tested area by a minimum of 3 inches (75mm).

4. All areas indicating leaks shall be repaired in accordance with Part 3.7.C.

5. Vacuum-tested seams shall be recorded on the Daily QC log.

C. Air Pressure Testing (dual hot wedge seams only)

1. Sustain a pressure of 24 to 30 psi within the air channel for 5 minutes.

2. If the loss of pressure exceeds 4 psi or does not stabilize, locate the faulty area and repair in accordance with Part 3.7.C.

3. Verify that the length of the tested channel is unobstructed by cutting the air channel at the opposite end of the pressure gauge.

4. Seal test holes with extrudate or patch.

3.9 GEOMEMBRANE PENETRATIONS

All geomembrane penetration details shall be as recommended by the geomembrane manufacturer, and as approved by the Construction Manager.

3.10 COVER SYSTEM COMPLETION

Upon completion and acceptance of the geomembrane in an area, the geomembrane shall be covered with the required materials within 14 days.

PART 4 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

4.1 QUALITY ASSURANCE

Perform work in accordance with the Construction Quality Assurance Plan.

4.2 QUALIFICATIONS

The minimum qualifications of the Manufacturer, Installer, Master Seamer, OC Inspector, and Independent Laboratory, as specified in Part 1.6, are to be submitted to the Construction Manager for review and approval.

4.3 MANUFACTURER QA/QC REQUIREMENTS

A. Tests, Inspections and Verifications

HDPE geomembrane shall be tested by the manufacturer prior to shipment to ensure that the physical and mechanical properties of the finished product are in accordance with these Specifications. Properties tested, test methods, and required values for the VFPE geomembrane are presented in Table 02290-1. Test frequency shall be in accordance with the manufacturer's quality control program, ASTM D4354, or as otherwise specified herein, whichever is more stringent.

4.4 CONTRACTOR QA/QC REQUIREMENTS

A. Daily Quality Control Log

The OC Inspector shall maintain a daily QC log during all phases of geomembrane installation. This log shall document the daily progression of the material installation from delivery to final acceptance. The daily log shall designate those construction activities that influence the integrity of the material during installation. The log, at a minimum, shall include entries and detailed documentation of the following:

1. Weather (temperature, winds, precipitation).
2. Preparation activities, including removal of water and sediment, geomembrane cleaning, or subbase smoothing and repair.
3. Results of daily trial seams.
4. Repairs and replacements.
5. Seaming activities, including name of welder(s) for each seam and any leakage detected in that seam.
6. Results and locations of destructive and non-destructive testing performed as part of geomembrane installation, including corrective action(s) taken.
7. Equipment used to place the geomembrane.
8. Inspection and backfilling of perimeter trenches.
9. Calibration dates for each seaming equipment and seam test equipment.
10. Names, dates, and times when the job site is visited by regulatory personnel.

11. Time periods, locations, and procedures administered when tents are used for geomembrane installation during periods of low temperature.
12. Quantities of materials placed/installed.
13. Subgrade acceptance forms, signed by the Installer, for each days deployment.
14. List of deployed and seamed panels by date.

B. Inspection of Geomembrane During Placement

During placement of the geomembrane, the QC Inspector shall carry out visual inspections of the material surface. Any defects relating to the geomembrane integrity, continuity, seaming, and panel placement/orientation shall be repaired by the Installer using the manufacturer's recommended techniques. Such repairs shall be reported to the Construction Manager by means of a daily quality control (QC) log.

- C. Prior to performing the Work, the Contractor shall submit the daily QC log format for approval by the Construction Manager.

4.5 RECORD DRAWINGS

At the completion of the work, the Contractor shall provide record drawings showing all panel and roll numbers, seam numbers, and the location of repairs and repair type, destructive seam samples, and penetrations. Record drawings shall also indicate the elevations of the center and top of the geomembrane and the horizontal limits of the geomembrane.

TABLE 02290-1
Required Properties of High Density Polyethylene (HDPE) Geomembrane

Property	Test Method	Required Minimum Value		Units
		Smooth	Textured	
Thickness (min. ave.) • lowest indiv. of 10 values	ASTM D 5199	60 -10	- -	mil %
Thickness (min. ave.) • lowest indiv. for 8 out of 10 values • lowest indiv. for any of the 10 values	ASTM D 5994	- - -	60 (-5) -10 -15	mil (%) % %
Asperity Height (min. ave.) ⁽¹⁾	GRI GM 12	-	10	mil
Density (min. ave.)	ASTM D 1505/ D 792	0.940 (GRI GM 13)		g/cc
Tensile Properties (min. ave.) ⁽²⁾ • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	126 228 12 700	126 90 12 100	lb/in lb/in % %
Tear Resistance (min. ave.)	ASTM D 1004	42		lb
Puncture Resistance (min. ave.)	ASTM D 4833	108	90	lb
Stress Crack Resistance ⁽³⁾	ASTM D 5397 (App.)	300		hr
Carbon Black Content (range)	ASTM D 1603 ⁽⁴⁾	2.0 – 3.0		%
Carbon Black Dispersion	ASTM D 5596	Note (5)		-
Oxidative Induction Time (OIT) (min. ave.) ⁽⁶⁾ (a) Standard OIT ---- or ---- (b) High Pressure OIT	ASTM D 3895	100 400		min min
Oven Aging at 85°C ^{(6), (7)} (a) Standard OIT (min. ave.) – % retained after 90 days ---- or ---- (b) High Pressure OIT (min. ave.) – % retained after 90 days	ASTM D 5721 ASTM D 3895	55 80		% %
UV Resistance ⁽⁸⁾ (a) Standard OIT (min. ave.) ---- or ---- (b) High Pressure OIT (min. ave.) – % retained after 1600 hours ⁽¹⁰⁾	ASTM D 7238 ASTM D 3895	N.R. ⁽⁹⁾ 50		- %

Notes:

- (1) Of 10 readings; 8 out of 10 must be ≥ 7 mils, and lowest individual reading must be ≥ 5 mils; also see Note (6)
- (2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.

Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches.
- (3) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing. P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
- (4) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.
- (5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3
- (6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
- (7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
- (8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4-hour condensation at 60°C.
- (9) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
- (10) UV resistance is based on percent retained value regardless of the original HP-OIT value.

TABLE 02290-2
Required High Density Polyethylene (HDPE) Geomembrane Seam Properties

Seam Type	Properties	Units	Required Minimum Values ^{(1), (2)}	Test Method
Dual Hot-Wedge Seaming	Shear Strength	lb/in	120	ASTM D 6392
	Peel Strength	lb/in	91	ASTM D 6392
Extrusion Fillet Seaming	Shear Strength	lb/in	120	ASTM D 6392
	Peel Strength	lb/in	78	ASTM D 6392

Notes:

- (1) Applicable to smooth and textured HDPE geomembrane.
- (2) Value listed for shear and peel strength are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values.

END OF SECTION

SECTION 02291

GAS COLLECTION/DRAINAGE GEOCOMPOSITE

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Manufacturing, furnishing and installing synthetic drainage media (geocomposite) material to be utilized for drainage within the final cover system of the Industrial Waste Landfill (IWL) and gas collection at two areas within the IWL containing biosolids, as indicated on the Drawings.
- B. The 'double-sided' drainage geocomposite, which has heat-bonded geotextile on the upper and lower sides of the geonet, shall be placed atop the textured geomembrane at the east slope of the IWL as a drainage layer. The 'double-sided' gas collection geocomposite, which has heat-bonded geotextile on the upper and lower sides of the geonet, shall be placed atop the subgrade to collect the landfill gas over the two areas within the IWL containing biosolids. For the remaining slopes and flat areas, the 'single-sided' drainage geocomposite, which has heat-bonded geotextile on the upper side of the geonet, shall be placed atop the smooth geomembrane as a drainage layer.

1.2 RELATED SECTIONS

- A. Section 01300 - Submittals
- B. Section 01400 - Quality Control and Quality Assurance
- C. Section 02000 - Site Work
- D. Section 02290 - Geomembrane for Final Cover System
- E. Section 02292 – Geotextiles
- F. Section 02295 - Direct Shear Interface Testing

1.3 MEASUREMENT AND PAYMENT

- A. Furnish and Install 'Double-sided' Geocomposite as a Landfill Gas Collection Layer: Unit Price. Includes supplying, storing, deploying, connecting, and anchoring 'double-sided' geocomposite material atop the subgrade over the two

areas within the IWL containing biosolids. No allowance will be made for waste or overlap. Actual installed quantity will be based on horizontal plan dimension shown on record survey. 'Double-sided' gas collection geocomposite installed and accepted by the Construction Manager will be paid for on a unit price basis in accordance with the Bid Schedule.

- B. Furnish and Install 'Double-sided' Geocomposite as a Drainage Layer: Unit Price. Includes supplying, storing, deploying, connecting, and anchoring 'double-sided' geocomposite material atop the textured geomembrane barrier layer of the cover system at the east slope of the IWL. No allowance will be made for waste or overlap. Actual installed quantity will be based on horizontal plan dimension shown on record survey. 'Double-sided' drainage geocomposite installed and accepted by the Construction Manager will be paid for on a unit price basis in accordance with the Bid Schedule
- C. Furnish and Install 'Single-sided' Geocomposite as a Drainage Layer: Unit Price. Includes supplying, storing, deploying, connecting, and anchoring 'single-sided' geocomposite material atop the smooth geomembrane barrier layer of the cover system at all slopes except the east slope and remaining flat areas of the IWL. No allowance will be made for waste or overlap. Actual installed quantity will be based on horizontal plan dimension shown on record survey. 'Single-sided' geocomposite installed and accepted by the Construction Manager will be paid for on a unit price basis in accordance with the Bid Schedule

1.4 REFERENCES

- A. ASTM D 413 – Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate
- B. ASTM D 1238 - Flow Rates of Thermoplastics by Extrusion Plastometer
- C. ASTM D 1505 - Density of Plastics by the Density-Gradient Technique
- D. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics
- E. ASTM D 1777 - Thickness of Textile Materials
- F. ASTM D 4218 - Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- G. ASTM D 4354 – Sampling of Geosynthetics for Sampling
- H. ASTM D 4716 - Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextile Related Products

- I. ASTM D 5199 - Measuring Normal Thickness of Geotextiles and Geomembranes
- J. ASTM D 5596 – Standard Practice for Microscopical Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
- K. ASTM D 7005 – Determining the Bond Strength (Ply Adhesion) of Geocomposites
- L. GRI GC-8 – Determination of the Allowable Flow Rate of a Drainage Geocomposite

1.5 SUBMITTALS

- A. Submit the following at least 30 days prior to delivery of first shipment:
 - 1. Certified test reports, including the results of at least two (2) transmissivity tests, within the requirements of standards of testing methods specified herein shall be submitted to the Construction Manager. The material Manufacturer and Contractor must satisfy the Construction Manager that the material they offer to furnish and install shall meet in every aspect the requirements set forth in these specifications and the requirements of Tables 02291-1 and 02291-2. The Contractor shall transmit to the Construction Manager all information given to them by the Manufacturer or Supplier prior to approval for furnishing and installing any such material.
 - 2. Manufacturer's quality control (QC) manual.
 - 3. Manufacturer's recommended installation procedures, including placement and joining.
 - 4. Properly identified 6-inch by 6-inch minimum size geocomposite samples with attached geotextiles.
 - 5. Full and complete installation shop drawings showing at a minimum:
 - a). Layout of landfill gas collection geocomposite.
 - b). Layout of drainage geocomposite
 - c). Details of joining panels.
 - d). Details for anchorage of material.

6. Certification of bond properties. See Part 2.1C for requirements of heat-bonding non-woven geotextiles to the upper side or both sides of the geonet (i.e., 'single-sided' and 'double-sided' geocomposite, respectively).
 7. Qualifications of geocomposite Manufacturer, Installer, QC Inspector, and Independent Laboratory. See Part 1.6 for requirements.
 8. Certification by geocomposite Manufacturer that the Installer is approved to install geocomposite materials.
- B. Submit the following on a daily basis during construction or on a frequency agreed to by the Contractor and Construction Manager:
1. Daily quality control log. See Part 4.6A for requirements.
- C. Submit the following at completion of construction:
1. Warranties for material and workmanship

1.6 QUALIFICATIONS

A. Manufacturer

The Manufacturer shall have produced the proposed geocomposite for at least 5 completed projects having a total minimum area of 10 million square feet.

B. Installer

The Installer is responsible for field handling, deploying, seaming, anchoring, and field QC testing of the geocomposite. The Installer shall have installed the proposed geocomposite material for at least 5 completed projects having a total minimum area of 2 million square feet.

C. QC Inspector

The QC Inspector is the person or corporation hired by the Contractor, who is responsible for monitoring and documenting activities related to the QC of the geocomposite from manufacturing through installation. The QC Inspector shall have provided QC inspection during installation of the proposed geocomposite material for at least 5 completed projects having a total minimum area of 2 million square feet.

D. Independent Laboratory

The Independent Laboratory shall have provided QC and/or Quality Assurance (QA) testing of the proposed geocomposite for at least five completed projects having a total minimum area of 2 million square feet. The Independent Laboratory shall be accredited via the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAILAP) for the tests the Independent Laboratory will be required to perform.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Materials shall be delivered to the site only after the required submittals have been approved by the Construction Manager. Storage and handling of the materials shall conform to the Manufacturer's recommendations and shall be done in such a manner as to prevent damage to any part of the Work or the material itself.
- B. The geocomposite materials shall be packaged, shipped, stored and handled ensuring that no damage is incurred. The Contractor shall be responsible for keeping the geocomposite free of dirt, dust, mud, or any other foreign material. Each roll shall be labeled with the Manufacturer's name, product identification, lot number, roll number, and roll dimensions.
- C. To prevent ultraviolet degradation of geocomposite geotextile, the protective wrapper on each geocomposite roll shall not be removed until the material is ready for installation. If the wrapper is damaged, the geocomposite shall be tarped.

PART 2 PRODUCTS

2.1 MATERIALS

- A. The polymer used to manufacture the geonet shall be non-thermally degraded, medium to high-density polyethylene which is clean and free of any foreign contaminants. The drainage net shall not be manufactured with a foaming agent.
- B. The geotextile of geocomposite shall comply with requirements specified in Section 02292 for filtration geotextile.
- C. Bond Properties: Geocomposite shall be created by heat-bonding geotextile to the upper or both sides of the geonet with ply adhesion meeting the requirements of ASTM D 7005. The bond between the geotextiles and the geonet shall exhibit minimum peel strength of 2 pounds per inch.

- D. The geonet shall be manufactured from two sets of parallel extruded polymer strands intersecting at a constant angle between 60 and 90 degrees. Strands of one set shall lie on top of strands of the other set, and the two sets shall be bonded at the intersection.
- E. Geocomposite ties shall be heavy-duty, high-strength polymer (nylon) braid ties. They should be brightly-colored (in contrasting color to the geocomposite) for easy inspection. Metallic fasteners will not be allowed.

**TABLE 02291-1
GEONET COMPONENT**

PROPERTY	TEST METHOD	UNITS	VALUE
Thickness	ASTM D 5199	inches	0.2
Density	ASTM D 1505	gm/sq-cm	0.935
Carbon Black Dispersion	ASTM D 5596	NA	(a)
Carbon Black Content	ASTM D 1603	percent	2.0 – 3.0

Notes:

- (a) = Carbon Black Dispersion for 10 different views
- Minimum 9 of 10 in categories 1 or 2
 - All 10 in categories 1, 2, or 3

**TABLE 02291-2
TRANSMISSIVITY**

PROPERTY	TEST METHOD ¹	UNITS	VALUE
Geocomposite	GRI Standard – GC8 (Hydraulic Gradient = 0.1, Normal Stress = 50 kPa)	m ² /sec	4.24 x 10 ⁻³

Notes:

- ¹ = The seating time should be of the order of 100 hours or more and the boundary conditions due to adjacent materials should be simulated during the transmissivity testing.

PART 3 EXECUTION

3.1 INSTALLATION

- A. No gas collection geocomposite shall be placed on subgrade that has become too soft, as determined by the Construction Manager, Contractor, Installer, or QC Inspector. Immediately prior to gas collection geocomposite, the Installer shall certify in writing that the surface on which the gas collection geocomposite is to be placed is acceptable.
- B. The geocomposite shall be laid out and installed by the Installer in accordance with the applicable shop drawings approved by the Construction Manager. The Installer shall be certified by the Manufacturer as accepted material installers. The Construction Manager's approval of the shop drawings does not relieve the Installer of their responsibility to properly install the geocomposite.
- C. The Installer shall deploy the geocomposite ensuring that the underlying material(s) are not damaged. Faulty or damaged material shall be replaced or repaired as specified, at no additional cost to the Owner. The material shall be unrolled downslope keeping the net in slight tension to minimize wrinkles and folds. The geocomposite shall be maintained free of dirt, mud, or any other foreign materials at all times during construction. Rolls which are contaminated with these materials shall be cleaned or replaced. Adequate loading (e.g. sandbags) shall be placed to prevent uplift by wind.
- D. Adjacent geocomposite panels shall be overlapped a minimum of 6 inches and securely fastened together with ties at a minimum of 5-foot intervals. Seaming of geocomposite panels shall be by sewing, adhesives, fusion, plastic-ties, or other Construction Manager-approved means. Cross-slope seams or end-of-panel seams shall be overlapped a minimum 6 inches and offset a minimum of 5 feet between adjacent roll ends and securely fastened together with ties at a maximum of 6-inch intervals. A fabric cap strip overlapping end of panel seams a minimum of 24-inches shall be thermally bonded to the upper layer of geotextile.
- E. Repairs: Holes or tears in the geocomposite shall be repaired by placing a patch of the same material extending a minimum of 2 feet in all directions beyond the edges of the hole or tear. Approved fasteners, spaced every 6 inches around the patch, shall be used to fasten the patch to the original roll.
- F. Penetrations: Penetration details shall be as shown on the Drawings, or otherwise recommended by the geocomposite Manufacturer and approved by the Construction Manager.

- G. No geocomposite shall be covered prior to acceptance by the Construction Manager. Upon completion and acceptance of the geocomposite in an area, the geocomposite shall be covered with the required materials within 5 days of acceptance in accordance with the Drawings and Specifications except that no geocomposite shall remain exposed for more than 14 days. Soil shall not be dropped from heights in excess of 3 feet atop the geocomposite materials.
- H. A minimum of 12 inches of soil shall be placed atop the drainage geocomposite and spread in advance of construction equipment not exceeding 8 psi contact pressure. The material shall be spread in the same direction at the geocomposite is seamed. Extreme care shall be required by the Contractor so that the equipment operator pushes the soil materials ahead without damage to the geocomposite. At no time shall any type of construction equipment or other vehicle, including, but not limited to, pickup trucks and ATV of any type or size, be permitted to track directly on any geocomposite. Any damage to the geocomposite shall be repaired by the Installer using methods approved by the Construction Manager at no additional cost to the Owner.
- I. During periods of high winds, sandbags or other methods approved by the Manufacturer shall be used by the Installer to temporarily secure any exposed geocomposite in place.

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

4.1 QUALITY ASSURANCE

Perform work in accordance with the Construction Quality Assurance Plan.

4.2 QUALIFICATIONS

The minimum qualifications of the Manufacturer, Installer, QC Inspector, and Independent Laboratory, as defined in Part 1.6, are to be submitted to the Construction Manager for review in accordance with Part 1.5.A.

4.3 MANUFACTURER'S SAMPLING AND TESTING

- A. Geocomposite testing shall be performed by the Independent Laboratory approved by the Construction Manager.
- B. Individual components (geotextile and geonet respectively) as well as the completed geocomposite shall be randomly sampled and tested by the Manufacturer, prior to shipment, to satisfy ASTM D 4354 but no less than at least once every 100,000 square feet to evaluate the required properties summarized in

Tables 02291-1, 02291-2 and 02292-1. Certified test results on each sample shall be submitted to the Construction Manager. If the samples do not meet the minimum requirements specified, the applicable rolls shall be rejected and should not be shipped to the project site by the Manufacturer.

4.4 INDEPENDENT CONFORMANCE TESTING

- A. Upon, or prior to, delivery of the rolls of geocomposite, the QA Consultant shall verify that samples are removed from the rolls which had already passed Manufacturer's sampling and testing (Section 4.3) and forwarded to the Independent Laboratory for testing to verify conformance with the test methods and results listed in Table 02291-3.

**TABLE 02291-3
CONFORMANCE TESTING REQUIREMENTS**

PRODUCT	PROPERTY	TEST METHOD	UNITS	VALUE
Geocomposite	Transmissivity	GRI Standard – GC8 ¹ (Hydraulic Gradient = 0.1, Normal Stress = 50 kPa)	m ² /sec	4.24×10^{-3}
Geocomposite	Ply Adhesion	ASTM D 7005	psi	2
Geonet Component	Thickness	ASTM D 5199	inches	0.2

Notes:

1 = The seating time should be of the order of 100 hours or more and the boundary conditions due to adjacent materials should be simulated during the transmissivity testing.

- B. Using the packing list provided by the Manufacturer rolls shall be selected for sampling at a minimum frequency of one sample per 100,000 square feet of material designated for the project. Each different manufacturing run or lot shall be represented by at least one sample.

4.5 CONFORMANCE TEST RESULTS

- A. If the average conformance test values for the sample meet all of the values given in Table 02291-3, the sample is acceptable.

- B. If the average conformance test values for the sample do not meet one or more of the required values, additional evaluation procedures will be implemented.
1. For the failing parameter(s), test two additional samples (a sample is defined by the number of specimens required for the specified test method). Another GAI Accredited Laboratory at the discretion of the QA Consultant and the Construction Manager may perform these tests.
 2. If the average test values for each of the two additional samples meet the required values, the roll and adjacent rolls are acceptable.
 3. If one or more of the average test values do not meet the requirements, reject the roll, collect samples from the closest numerical roll on both sides of the failed roll and test for the failed parameter(s). If testing continues to not meet the requirements the Construction Manager shall determine further testing protocol for identifying the limits of rejected rolls or may reject the entire lot of material.

4.6 CONTRACTOR QA/QC REQUIREMENTS

A. Daily Quality Control Log

The QC Inspector shall maintain a daily quality control log during all phases of geocomposite installation. This log shall document the daily progression of the material installation from delivery to final acceptance. The daily log shall designate those construction activities that influence the integrity of the material during installation. The log, at a minimum, shall include entries and detailed documentation of the following:

1. Weather (temperature, winds, precipitation)
2. Preparation activities.
3. Document that the roll number and sheet lot number are placed in the required panel locations
4. Repairs and replacements.
5. Document seaming or joining activities.
6. Equipment used to place the geocomposite.
7. Inspection and backfilling of perimeter trenches.

B. Inspection of Geocomposite During Installation

During placement of geocomposite material, the QC Inspector shall carry out visual inspections of the material surface. Any faulty areas relating to geocomposite integrity, continuity, overlapping/joining technique, and panel placement/orientation shall be repaired by the Installer using pre-approved techniques, at no additional cost to the Owner. Such repairs shall be reported to the Construction Manager by means of a daily quality control (QC) log.

END OF SECTION

SECTION 02292

GEOTEXTILES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Geotextile materials used for separation, bedding, and filtration purposes, as indicated on the Drawings.
- B. Geotextile heat-bonded to drainage geonet to form either 'single-sided' or 'double-sided' geocomposite shall consist of filtration geotextile.

1.2 RELATED SECTIONS

- A. Section 01300 - Submittals
- B. Section 01400 - Quality Control and Quality Assurance
- C. Section 02000 - Site Work
- D. Section 02270 - Soil Erosion and Sediment Control Measures
- E. Section 00280 - Prefabricated Vertical Drains
- F. Section 02290 - Geomembrane for Final Cover System
- G. Section 02291 - Gas Collection/Drainage Geocomposite
- H. Section 02295 - Direct Shear Interface Testing

1.3 MEASUREMENT AND PAYMENT

- A. Furnish and Install Filtration Geotextile Heat-Bonded to the Upper Side of the Geonet to Form 'Single-Sided' Drainage Geocomposite: Heat-bonded filtration geotextile to the upper side of the geonet is a component of 'single-sided' geocomposite and will be measured and paid in accordance with Section 02291.)
- B. Furnish and Install Filtration Geotextile Heat-Bonded to the Upper and Lower Sides of the Geonet to Form 'Double-Sided' Gas Collection or Drainage Geocomposite: Heat-bonded filtration geotextile to the upper and lower sides of the geonet is a component of 'double-sided' geocomposite and will be measured and paid in accordance with Section 02291.)

- C. Furnish and Install Bedding Geotextile on Bottom Side of Geomembrane: Unit Price. Includes supplying, storing, installing, seaming, and anchoring bedding geotextile above the interim cover soil layer of the final cover system. Allowance will be made for geotextile in anchor and drainage trenches; however, no allowance will be made for waste or overlap. Actual installed quantity will be based on horizontal plan dimension shown on as-built survey. Bedding geotextile installed and accepted by the Construction Manager will be paid for on a unit price basis in accordance with the Bid Schedule.

1.4 REFERENCES

- A. ASTM D 3776 - Mass Per Unit Area (Weight) of Woven Fabric
- B. ASTM D 3786 - Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics : Diaphragm Bursting Strength Tester Method
- C. ASTM D 4354 - Sampling of Geosynthetics for Testing
- D. ASTM D 4355 - Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
- E. ASTM D 4491 - Water Permeability of Geotextiles by Permittivity
- F. ASTM D 4533 - Trapezoid Tearing Strength of Geotextiles
- G. ASTM D 4632 - Grab Breaking Load and Elongation of Geotextiles
- H. ASTM D 4751 - Apparent Opening Size of a Geotextile
- I. ASTM D 4759 - Specification Conformance of Geosynthetics
- J. ASTM D 4833 - Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
- K. ASTM D 4873 - Identification, Storage, and Handling of Geotextiles
- L. ASTM D 4884 - Seam Strength of Sewn Geotextiles
- M. ASTM D 5199 - Measuring Normal Thickness of Geotextiles and Geomembranes
- N. ASTM D 5261 – Measuring Mass Per Unit Area of Geotextiles

1.5 SUBMITTALS

- A. Submit the following for approval at least 30 days prior to delivery of first

shipment:

1. Certified test reports within the requirements of standards and testing methods specified herein shall be submitted for approval for each geotextile proposed for this project. The material Manufacturer and Contractor must satisfy the Construction Manager that the materials they offer to furnish and install shall meet in every aspect the requirements set forth in these specifications and the requirements of Table 02292-1, Table 02292-2, Table 02292-3, respectively. The Contractor shall transmit to the Construction Manager all information given to them by the Manufacturer or Supplier prior to approval for furnishing and installing any such material.
2. Manufacturer's quality assurance/quality control (MQA/QC) procedures to detect and remove needle(s) for all non-woven, needle-punched geotextile material. Any and all non-woven, needle-punched geotextile material for which no MQA/QC for needle detection is provided will not be accepted.

1.6 QUALIFICATIONS

- A. See Part 1.6 of Section 02291.

1.7 DELIVERY, STORAGE AND HANDLING

- A. See Part 1.7 of Section 02291.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Woven geotextile for use as a separation layer (as indicated on the Drawings) shall be provided to equal or exceed the physical and mechanical property values outlined below:

**Table 02292-1
SEPARATION GEOTEXTILE**

<u>Property</u>	<u>Minimum Value</u>
1. Mass per Unit Area (ASTM D 5261)	5.9 oz/sy

2. Thickness (ASTM D 5199)	13 mils
3. Puncture Resistance (ASTM D 4833)	120 lb
4. Grab Tensile Strength (ASTM D 4632)	370 × 250 lbs
5. Trapezoidal Tear Strength (ASTM D 4533)	100 × 70 lbs
6. Ultraviolet Degradation (ASTM D 4355)	90% strength retained at 500 hours

- B. Non-woven, needle-punched geotextile for use as bedding (as indicated on the Drawings) shall be provided to equal or exceed the physical and mechanical property values outlined below:

**Table 02292-2
BEDDING GEOTEXTILE**

<u>Property</u>	<u>Minimum Value</u>
1. Mass per Unit Area (ASTM D 5261)	12 oz/sy
2. Puncture Resistance (ASTM D 4833)	100 lb
3. Grab Tensile Strength (ASTM D 4632)	270 lb/50%
4. Trapezoidal Tear Strength (ASTM D 4533)	100 lb
5. Ultraviolet Degradation (ASTM D 4355)	70% strength retained at 500 hours

- C. Non-woven, needle-punched geotextile heat-bonded to the geonet for use as filtration shall be provided to equal or exceed the physical and mechanical property values outlined below:

**Table 02292-3
FILTRATION GEOTEXTILE**

<u>Property</u>	<u>Minimum Value</u>
1. Mass per Unit Area (ASTM D 3776)	8 oz/sy
2. AOS (ASTM D 4751)	No, 10 sieve or smaller
3. Puncture Resistance (ASTM D 4833)	70 lb
4. Permittivity (ASTM D 4491)	0.5 sec ⁻¹
5. Grab Tensile Strength (ASTM D 4632)	180 lb/50%
6. Trap Tear Strength (ASTM D 4533)	70 lb
7. Ultraviolet Degradation (ASTM D 4355)	70% strength retained at 500 hours

B. Thread: When sewn seams are applied, high-strength polyester, nylon, or other approved thread type shall be used. Thread shall have equivalent chemical compatibility and ultraviolet light stability as the geotextile and the color shall contrast with the geotextile for easy inspection. The minimum break strength of the thread shall be 50 pounds.

PART 3 EXECUTION

3.1 INSTALLATION A. See Part 3.1 of Section 02291.

- B. No bedding geotextile shall be placed on a subgrade that has become too soft, as determined by the Construction Manager, Contractor or QC Inspector. Immediately prior to bedding geotextile placement, the Installer shall certify in writing that the surface on which the bedding geotextiles are to be placed is acceptable.
- C. Sewn Seams: Shall be continuously sewn using a flat seam with one row of a two-thread chain stitch unless otherwise recommended by the Manufacturer. The minimum distance from the geotextile edge to the stitch line nearest to that edge shall be 3 inches unless otherwise recommended by the Manufacturer. The thread at the end of each seam run shall be tied off to prevent unraveling. Seams shall be on the top side of the geotextile to allow inspection. Skipped stitches or discontinuities shall be sewn with an extra line of stitching with 18 inches of overlap on each side of the defective seam.

PART 4 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

4.1 QUALITY ASSURANCE

Perform work in accordance with the Construction Quality Assurance Plan.

4.2 QUALIFICATIONS

See Part 4.2 of Section 02291.

4.3 MANUFACTURER SAMPLING AND TESTING

A. See Part 4.3 of Section 02291.

4.4 INDEPENDENT CONFORMANCE TESTING

A. See Part 4.4 of Section 02291.

4.5 TEST RESULTS

A. See Part 4.5 of Section 02291.

4.6 CONTRACTOR QA/QC REQUIREMENTS

A. See Part 4.6 of Section 02291.

END OF SECTION

SECTION 02295

DIRECT SHEAR INTERFACE TESTING

PART 1 GENERAL

1.1 SECTIONS INCLUDED

- A. Direct Shear Interface Laboratory Testing of Soils and Geosynthetic Materials

1.2 RELATED SECTIONS

- A. Section 01300 - Submittals
- B. Section 01400 – Quality Control and Quality Assurance
- C. Section 02206 – Geomembrane for Final Cover System
- D. Section 02291 – Gas Collection/Drainage Geocomposite
- E. Section 02292 - Geotextiles

1.3 MEASUREMENT AND PAYMENT

- A. Direct Shear Interface Laboratory Testing: Cost incidental to the supply and installation of geosynthetic components.

1.4 REFERENCES

- A. ASTM D 5321 – Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

1.5 SUBMITTALS

- A. Submit the following at least 30 days prior to delivery of first shipment of geosynthetic materials:
 - 1. Certified test results. (Initial Test)
 - 2. Statement of Qualifications for Testing Laboratory.
 - 3. Quality Assurance Plan.

- C. Submit the following during construction:
 - 1. Certified test results. (Interim Tests)

1.6 QUALIFICATIONS

- A. Independent Laboratory: Shall be independent from the Manufacturer, Installer and Contractor and shall be responsible for performing direct shear testing as required herein. The Independent Laboratory shall be subject to approval by the Construction Manager.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.1 TESTING REQUIREMENTS

- A. All tests shall be performed in accordance with ASTM D5321.
- B. The interface between 'double-sided' geocomposite and textured 60-mil HDPE geomembrane shall be tested.
 - 1.
 - 2.
 - 3.
- C. The materials tested shall be identical to the materials proposed for use on the project.
- D. The following test specifications are to be followed:
 - 1. Strain Rate: 0.04 in/min.
 - 2. Normal Loads: 100 psf, 200 psf, and 500 psf
 - 3. Saturate all interfaces prior to and during testing.
 - 4. Plot peak and residual shear stress versus normal compressive stress.

5. Connect data points for both peak and residual stresses, with a best fit line, through the origin, and report according to procedures in ASTM D 5321 – Section 13.
 6. Report asperity height of textured geomembrane at every testing.
- E. The Contractor shall perform at least 2 series of direct shear tests:
1. Prior to material delivery using identical materials. (Initial Test)
 2. During construction using materials delivered to the project. (Interim Tests)
- F. After completion of Initial Testing, the Independent Laboratory shall provide a minimum of three (3) copies of a summary report outlining the test preparations, conditions, procedures and results including applicable graphs, photographs, and figures. The test summary report shall be provided to the Construction Manager for review two (2) weeks prior to installation of the geomembrane. If review of the initial testing results indicate the geosynthetic materials do not meet the acceptance criteria, additional interface testing may be required by the Construction Manager at the Contractor's expense.
- G. Acceptance Criteria: The minimum required residual interface friction angle between 'double-sided' geocomposite and textured 60-mil HDPE geomembrane is 17°. Final acceptance of the material will be based upon the Construction Manager's review of the test reports described in this Section.
- H. If tested materials fail to achieve the required minimum interface friction angle, the Contractor shall select other materials meeting the specifications and repeat the friction testing.

END OF SECTION

SECTION 02831

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Fence framework, fabric, and accessories.
- B. Excavation for post bases; concrete foundation for posts, and center drop for gates.
- C. Manual gates and related hardware.

1.2 RELATED SECTIONS

- A. Section 02100 - Site Preparation.

1.3 LUMP SUM PRICE - MEASUREMENT AND PAYMENT

- A. Relocation of Existing Chain Link Fence: Lump Sum. Includes removing, relocating and re-installing the existing chain link fence and provision of any necessary new fence as indicated on the Drawings, and as necessary to complete the Work. This item shall also include the installation of temporary fence during construction, as specified in section 02100, to secure the site perimeter along the existing fence line during non-work hours. Fence work accepted by the Construction Manager will be paid for on a lump sum basis in accordance with the Bid Schedule.

1.4 REFERENCES

- A. ASTM A116 - Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric.
- B. ASTM A123 - Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
- C. ASTM A153 - Zinc Coating (Hot Dip) on Iron and Steel Hardware.
- D. ASTM A392 - Zinc-Coated Steel Chain-Link Fence Fabric.
- E. ASTM A446 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality.
- F. ASTM C94 - Ready-mixed Concrete.

- G. ASTM F567 - Installation of Chain-Link Fence.
- H. ASTM F669 - Strength Requirements of Metal Posts and Rails for Industrial Chain Link Fence.
- I. ASTM F1083 - Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structure.

1.5 SYSTEM DESCRIPTION

- A. Match existing fence.
- B. Fence Height: 8 feet nominal.
- C. Line Post Spacing: At intervals not exceeding 10 feet.
- D. Fence Post and Rail Strength: Conform to ASTM F669 Heavy Industrial Fence quality.

1.6 SUBMITTALS

- A. Product Data: Provide data on fabric, posts, accessories, fittings and hardware for temporary and new permanent fencing, as appropriate.
- B. Shop Drawings: Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, and schedule of components.
- C. Manufacturer's Installation Instructions: Indicate installation requirements for temporary and new permanent fencing, as appropriate.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Fabric: 96" 2" x 9 gauge galvanized fabric.
- B. Top Rail: None.
- C. Line Post: 2 1/2" O.D. SS-20 pipe, 2.29 lbs. per foot. Line posts set 10' on center maximum spacing. Concrete footing: 10" diameter, 36" depth.
- D. Terminal Post: 3" O.D. SS-20 pipe, 3.25 lbs. per foot. Concrete footing: 10" diameter, 36" depth.

- E. Bracing: Terminal posts braced to the nearest line post with 1 5/8" O.D. SS-20 pipe.
- F. Tension Wire: 7 gauge coil spring galvanized tension wire attached to top and bottom of fence fabric with 11 1/2 gauge steel (200/lb) hog ring spaced 18" on center.
- G. Fittings: Beveled brace band and carriage bolt, PS rail-end, PS loop-cap, PS post cap, 3/16" x 3/4" tension bar, beveled tension band and carriage bolt.
- H. Tie Wire: 8 1/4" 9 gauge aluminum tie wire and 6 1/2" 9 gauge aluminum tie wire spaced 14" on center for line posts and 18" on center for rails.
- I. Post Footing: Truck poured concrete.

PART 3 EXECUTION

3.1 REMOVAL AND RE-INSTALLATION OF EXISTING FENCING

- A. Remove fencing as required to complete the work.
- B. Carefully remove fence fabric to minimize damage and store as appropriate. Minimize damage to and removal of fence posts.
- C. Re-install fence in-kind.

3.2 INSTALLATION OF NEW PERMANENT FENCE (AS NECESSARY)

- A. Install framework, fabric, accessories and gates in accordance with ASTM F567 where necessary to replace damaged existing fence.
- B. Place fabric on outside of posts and rails.
- C. Set intermediate, terminal and gate posts plumb, in concrete footings with top of footing 2 inches above finish grade. Slope top of concrete for water runoff.
- D. Line Post Footing Depth Below Finish Grade: ASTM F567, 3 feet.
- E. Corner and Terminal Post Footing Depth Below Finish Grade: ASTM F567, 3'6".
- F. Install center brace rail on corner gate leaves.
- G. Do not stretch fabric until concrete foundation has cured 14 days.

- H. Stretch fabric between terminal posts or at intervals of 100 feet maximum, whichever is less.
- I. Position bottom of fabric 2 inches above finished grade.
- J. Attach fabric to end and corner posts with tension bars and tension bar clips.
- K. Install bottom tension wire stretched taut between terminal posts.

3.3 ERECTION TOLERANCES

- A. Maximum Variation From Plumb: 1/4 inch.
- B. Maximum Offset From True Position: 1 inch.
- C. Components shall not infringe adjacent property lines.

3.4 SCHEDULES

- A. Property Perimeter: 8 feet high.

END OF SECTION

SECTION 02900

MONITORING WELLS MODIFICATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Monitoring Well Extension
- B. Monitoring Well Reduction
- C. Survey Wells

1.2 RELATED SECTIONS

- A. Section 01300 – Submittals
- B. Section 02100 – Site Preparation

1.3 MEASUREMENT AND PAYMENT

- A. Modifying existing monitoring wells
 - 1. Basis of Measurement: Total number modified
 - 2. Basis of Payment: Lump Sum

1.4 SUBMITTALS

- A. Submit product information satisfying the requirements of this section to the Construction Manager for approval.

1.5 QUALIFICATIONS

- A. Well modifications shall be performed by a Delaware-licensed water well contractor.
- B. Professional land surveyor registered in the State of Delaware.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Materials shall be delivered to the site only after the required submittals have been approved by the Construction Manager. Storage and handling of materials shall conform to the manufacturer's recommendations and shall be done in such a manner as to prevent damage to any part of the Work or material itself. Materials shall be stored either on plastic sheeting or elevated above the ground surface.

PART 2 PRODUCTS

2.1 MATERIALS – MONITORING WELL EXTENSION

- A. 4-inch Polyvinyl chloride (PVC) slip x slip coupling.
- B. Variable lengths of Schedule 40, 4-inch inside-diameter PVC well casing.
- C. Stainless steel screws to secure coupling to well casings.
- D. Minimum 6-inch inside diameter steel stick-up protective casing with locking cap.
- E. 100 pounds Portland cement/5 pounds powdered bentonite mixed with 8 gallons of water to backfill area around well once final grading is completed.
- F. 2-feet long x 2-feet wide x 1-foot thick concrete anti-percolation pad around base of protective casing once final grading has been completed.
- G. Three (3) minimum 4-inch diameter steel "bumper posts" at each well location which is extended above grade. Posts shall be installed in a minimum 8-inch diameter excavation, a minimum of 4-feet deep and filled with concrete following installation.

2.2 MATERIALS – MONITORING WELL REDUCTION

- A. Minimum 8-inch diameter water-tight steel protective casing with minimum 12-inch long sheet metal skirting and bolt down lid.
- B. 100 pounds Portland cement/5 pounds powdered bentonite mixed with 8 gallons of water to backfill area excavated around well during well reduction.
- C. 2-feet long x 2-feet wide x 1-foot thick concrete anti-percolation pad around base of protective casing once final grading has been completed.

PART 3 EXECUTION

3.1 MONITORING WELL EXTENSION

- A. Monitoring well extension shall be performed as shown on the Drawings.
- B. Each protective well casing that is extended above grade will be surrounded by three (3) steel "bumper posts" as stated in Section 2.1 G.
- C. Components of the monitoring wells to remain during the monitoring well extension shall be protected from damage.

3.2 MONITORING WELL REDUCTION

- A. Monitoring well reduction shall be performed as shown on the Drawings.
- B. Following completion of the anti-percolation pad, each well that has been reduced to grade shall be barricaded in a manner to prohibit vehicular or pedestrian traffic until the concrete pad has been allowed to cure a minimum of 24 hours.
- C. Components of the monitoring wells to remain during the monitoring well reduction shall be protected from damage.

3.3 SURVEY WELLS

- A. The monitoring wells shall be surveyed and the top of casing elevations recorded by a professional land surveyor registered in the State of Delaware following a monitoring well modification.

PART 4 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Quality assurance/quality control of the monitoring well modifications shall be in accordance with the Construction Quality Assurance Plan and as directed by the Construction Manager.

END OF SECTION